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(12) **United States Patent**
Wiker et al.

(10) **Patent No.: US 8,281,779 B2**
(45) **Date of Patent: Oct. 9, 2012**

(54) **CONVEYOR OVEN APPARATUS AND METHOD**

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(73) Assignee: **Middleby Corporation**, Elgin, IL (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 26 days.

(21) Appl. No.: **12/233,969**

(22) Filed: **Sep. 19, 2008**

(65) **Prior Publication Data**

US 2009/0075224 A1 Mar. 19, 2009

Related U.S. Application Data

(63) Continuation of application No. 11/526,133, filed on Sep. 22, 2006, which is a continuation of application No. PCT/US2006/022304, filed on Jun. 8, 2006, and a continuation-in-part of application No. PCT/US2005/038783, filed on Oct. 27, 2005, and a continuation-in-part of application No. PCT/US2005/009546, filed on Mar. 23, 2005.

(60) Provisional application No. 60/555,474, filed on Mar. 23, 2004.

(51) **Int. Cl.**
F24C 15/32 (2006.01)

(52) **U.S. Cl.** ..... **126/21 A**; 432/126; 432/195; 99/443 C; 99/443 R; 99/360; 99/327; 99/389

(58) **Field of Classification Search** ..... 126/21 A; 432/126, 195; 99/443 C, 443 R, 360, 327, 99/389

See application file for complete search history.

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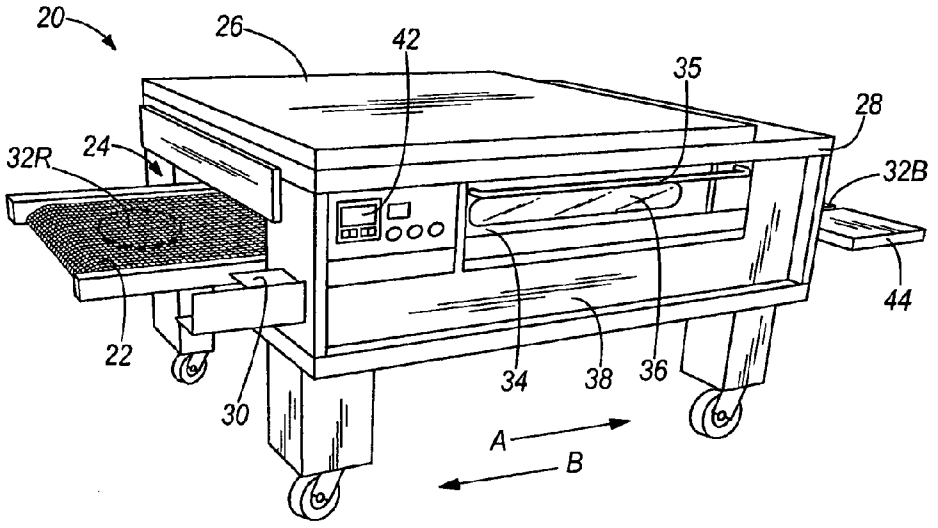
(57) **ABSTRACT**

An oven according to some embodiments includes an oven chamber in which food is cooked, a heating element, a fan, a sensor for sensing the temperature of the oven chamber, a remote input device, and a controller configured to receive a signal from the remote input device and to change the fan or heating element based at least in part upon the signal received from the remote input device. In a method of operating the oven according to some embodiments, the oven enters an operating mode from an energy-savings mode responsive to receiving an signal from a remote device.

61 Claims, 25 Drawing Sheets



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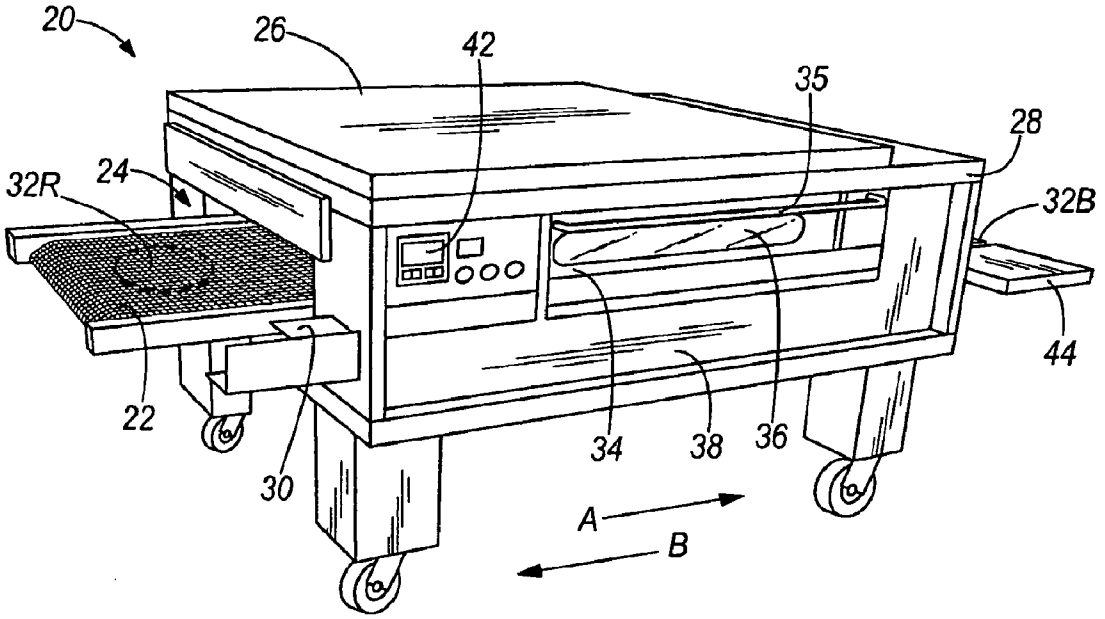

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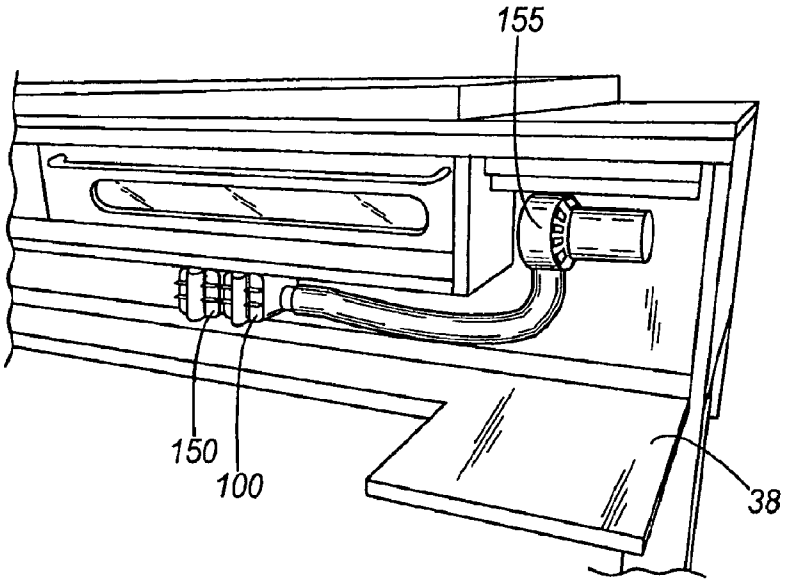
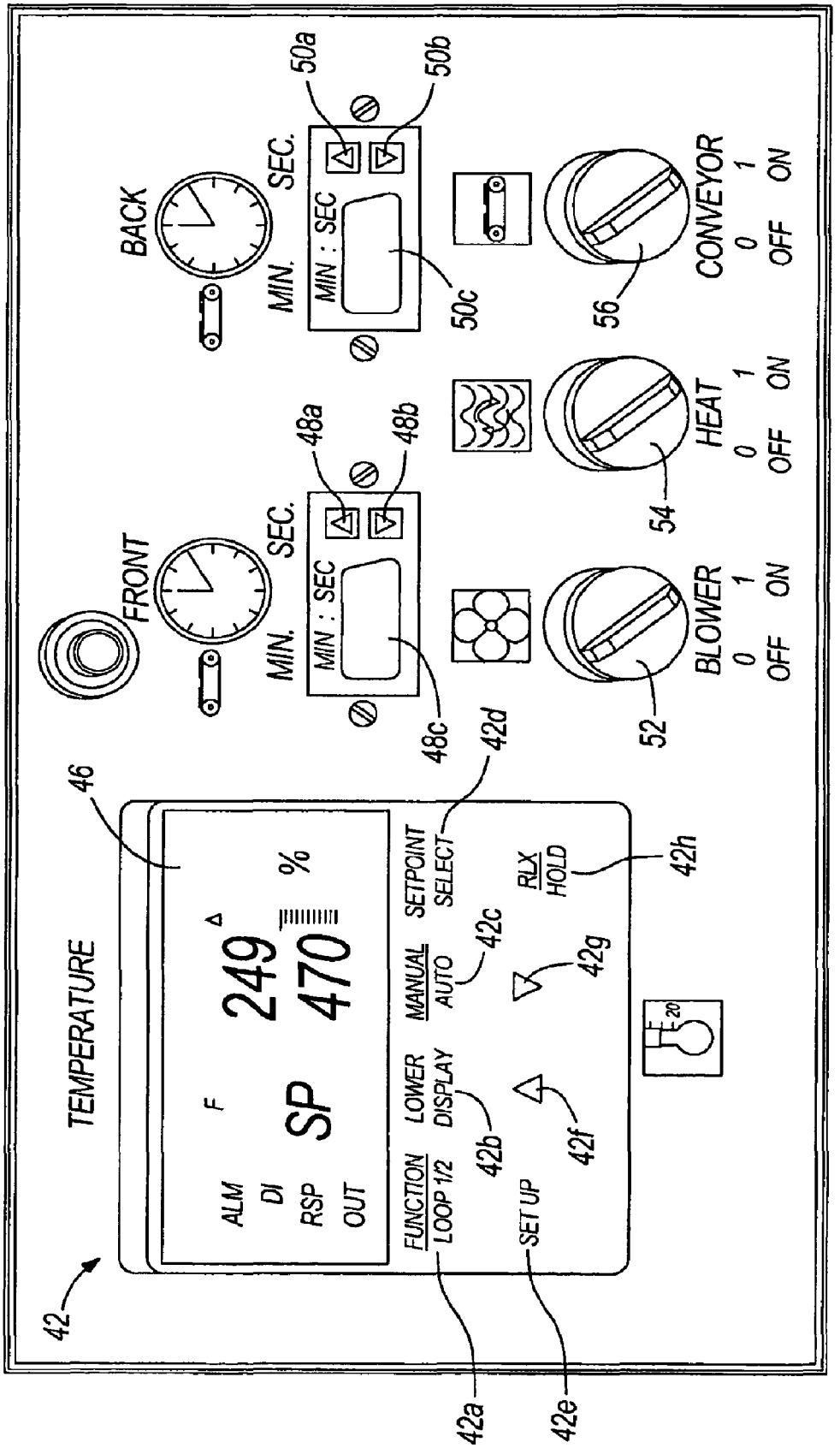


FIG. 2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SP
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%
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SELECT
RLX
HOLD
SET UP
BACK
MIN.
SEC.
MIN : SEC
FRONT
MIN.
SEC.
MIN : SEC
BLOWER
0 OFF
1 ON
HEAT
0 OFF
1 ON
CONVEYOR
0 OFF
1 ON
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42b
42c
42d
42e
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42g
42h
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48a
48b
48c
50a
50b
50c
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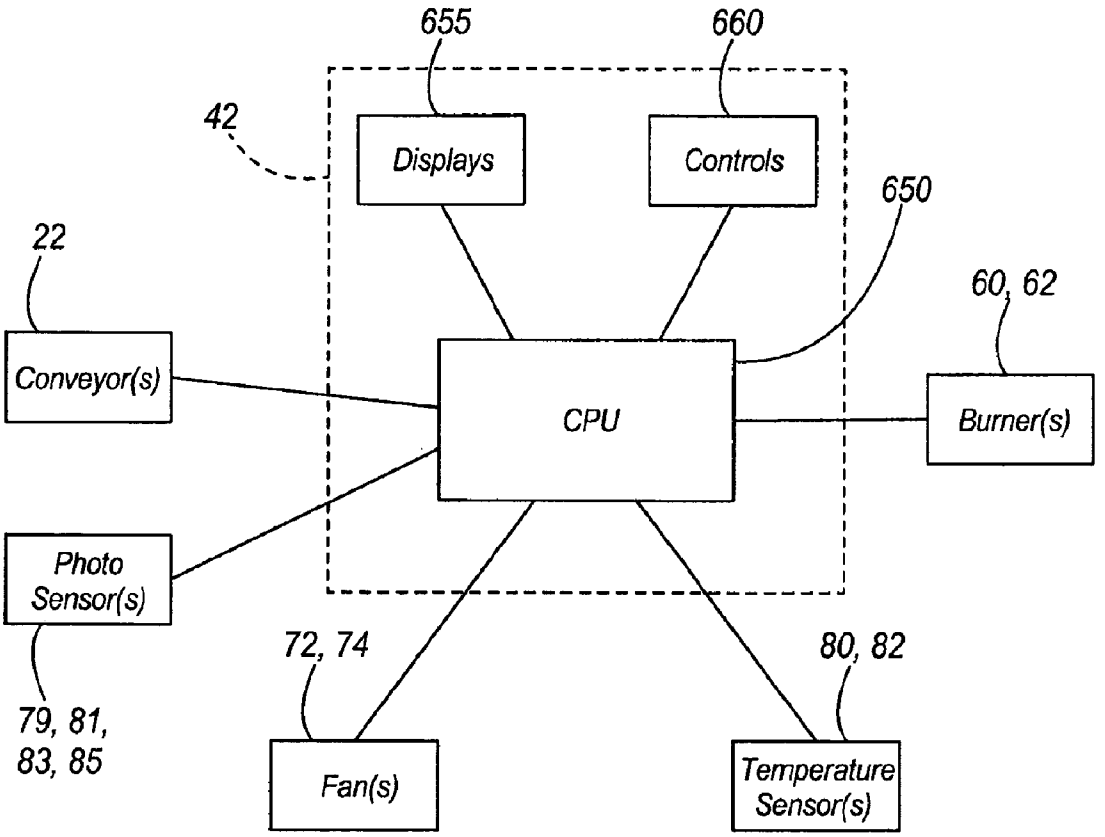
56

FIG. 3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42
Displays
Controls
650
22
60, 62
Conveyor(s)
CPU
Burner(s)
Photo Sensor(s)
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80, 82
79, 81, 83, 85
Fan(s)
Temperature Sensor(s)

FIG. 3A

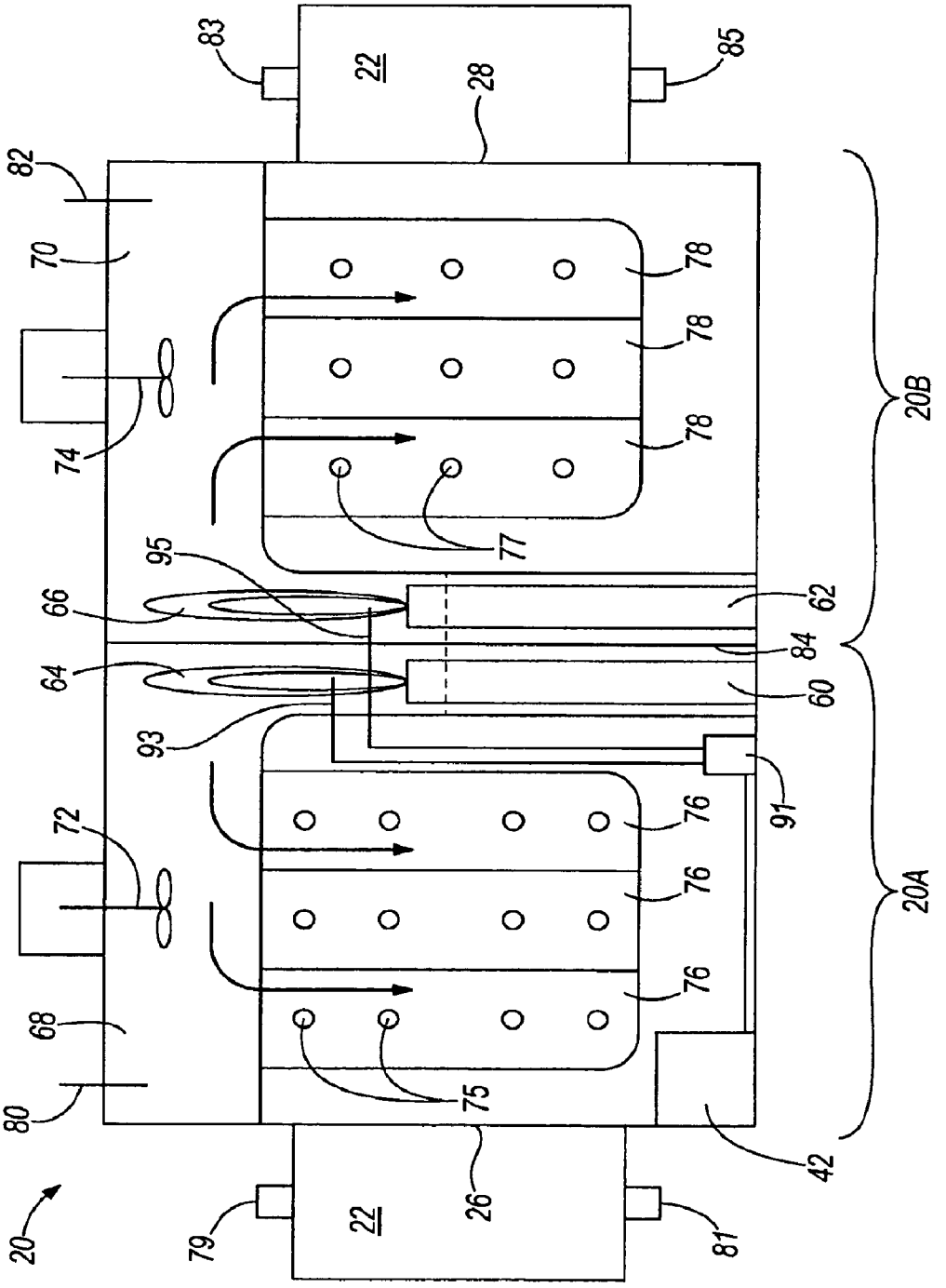
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FIG. 4

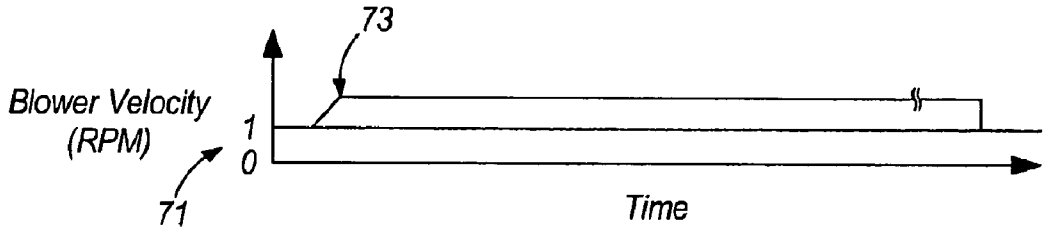

FIG. 5A

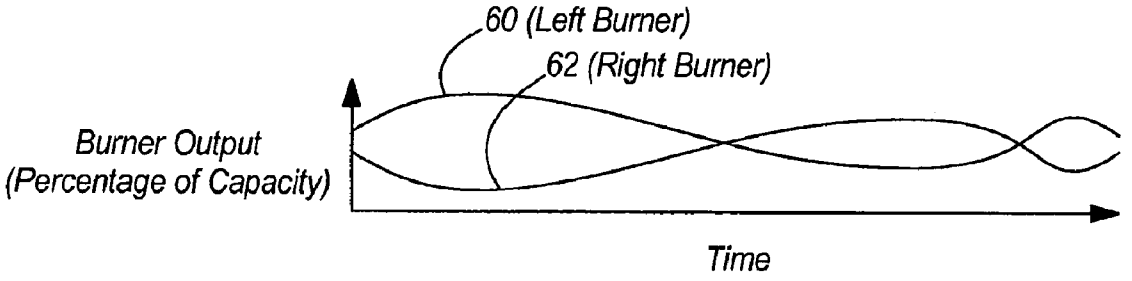

FIG. 5B

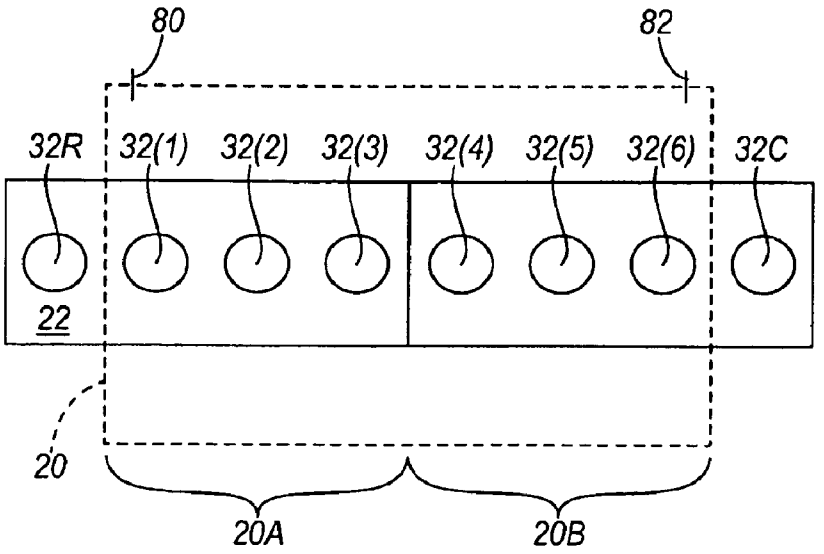

FIG. 5C

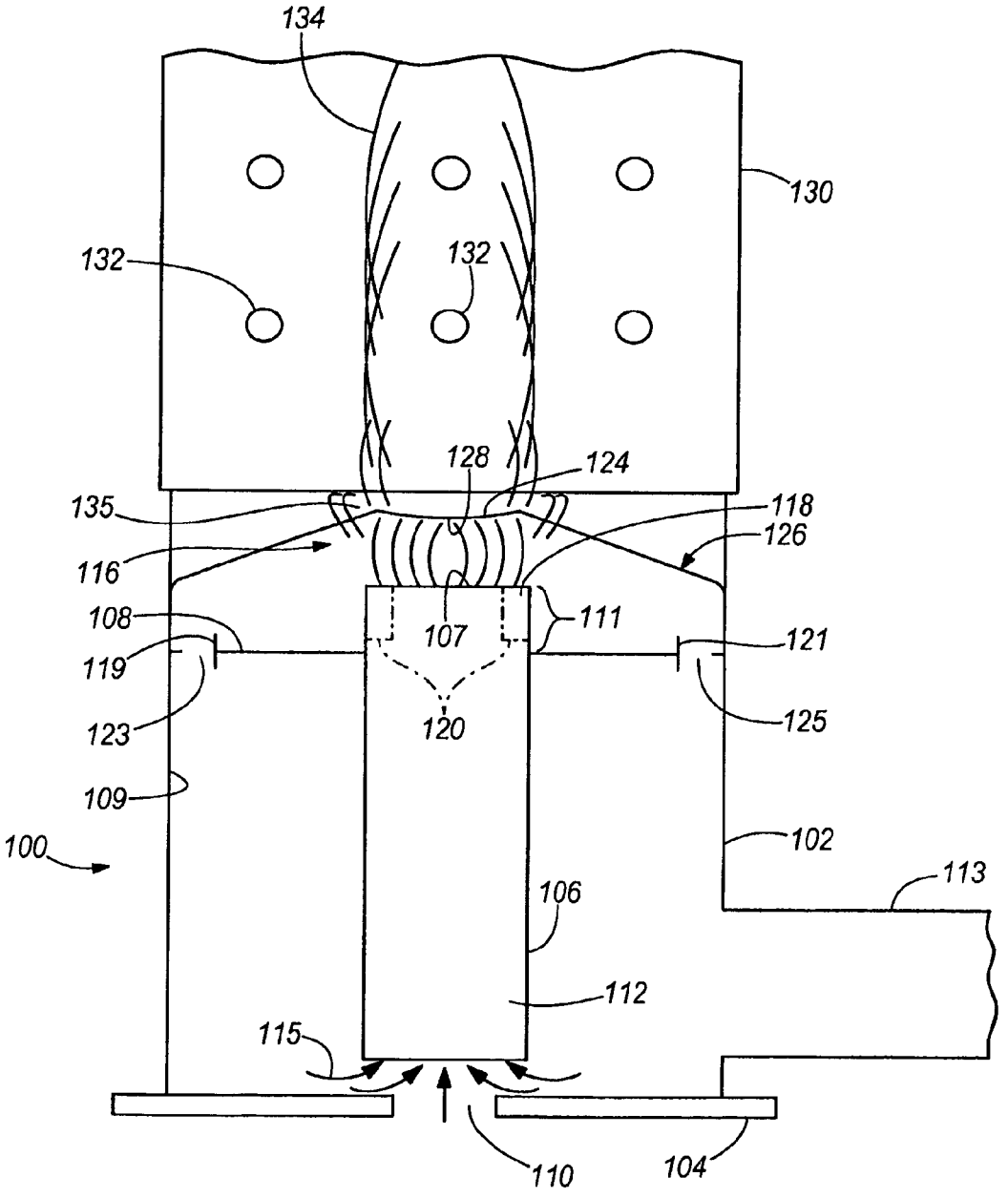
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FIG. 6

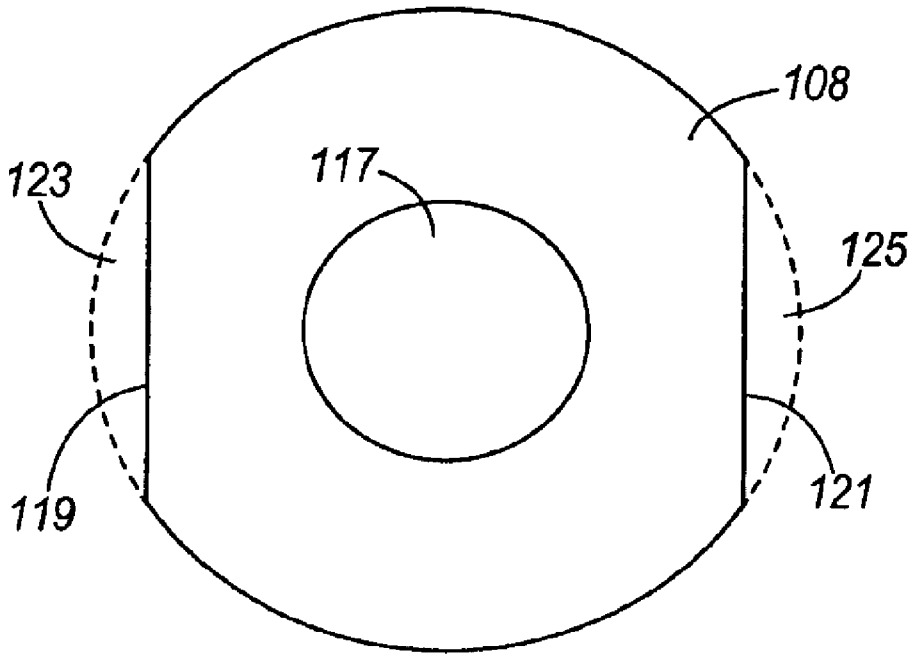

FIG. 6A

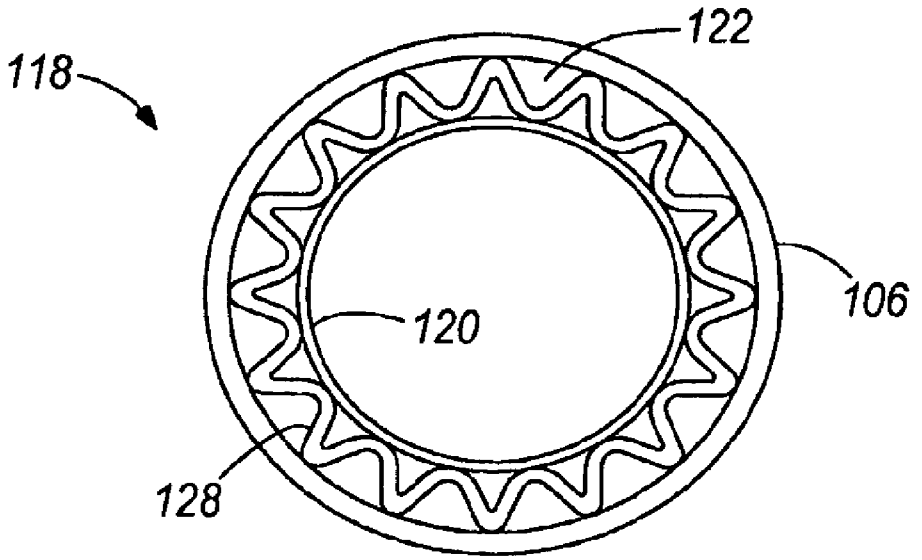

FIG. 6B

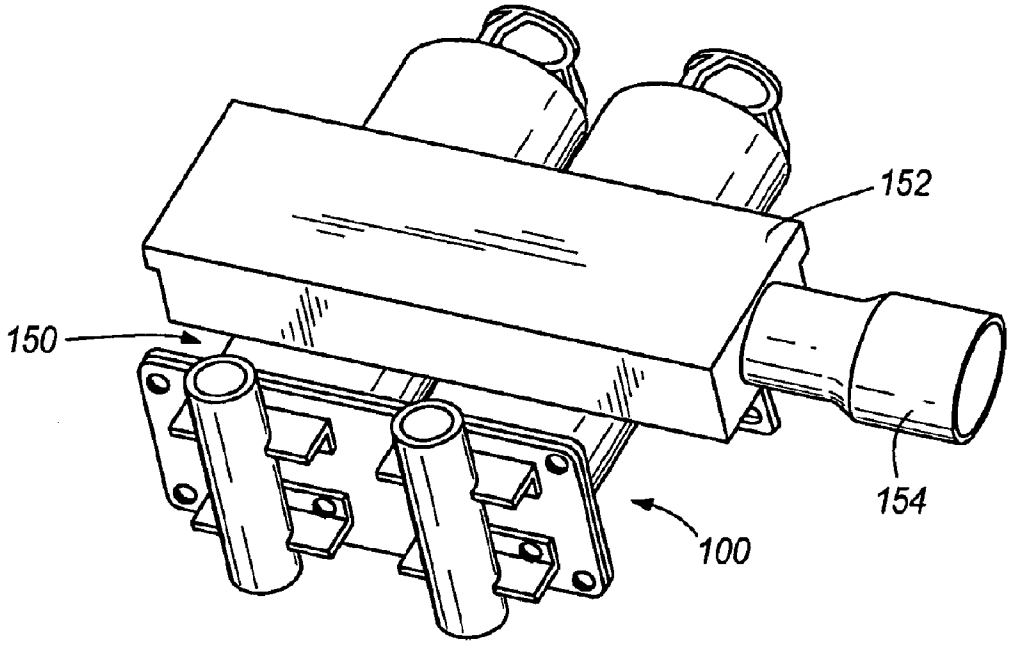
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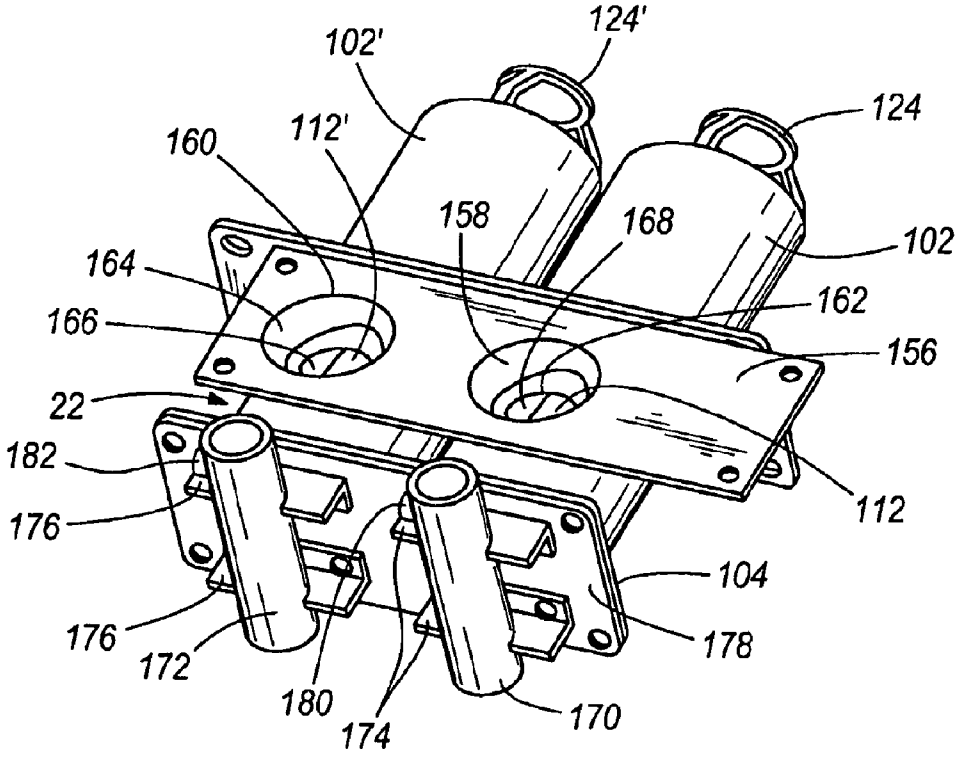
FIG. 7A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112'
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182
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172
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174
170

FIG. 7B

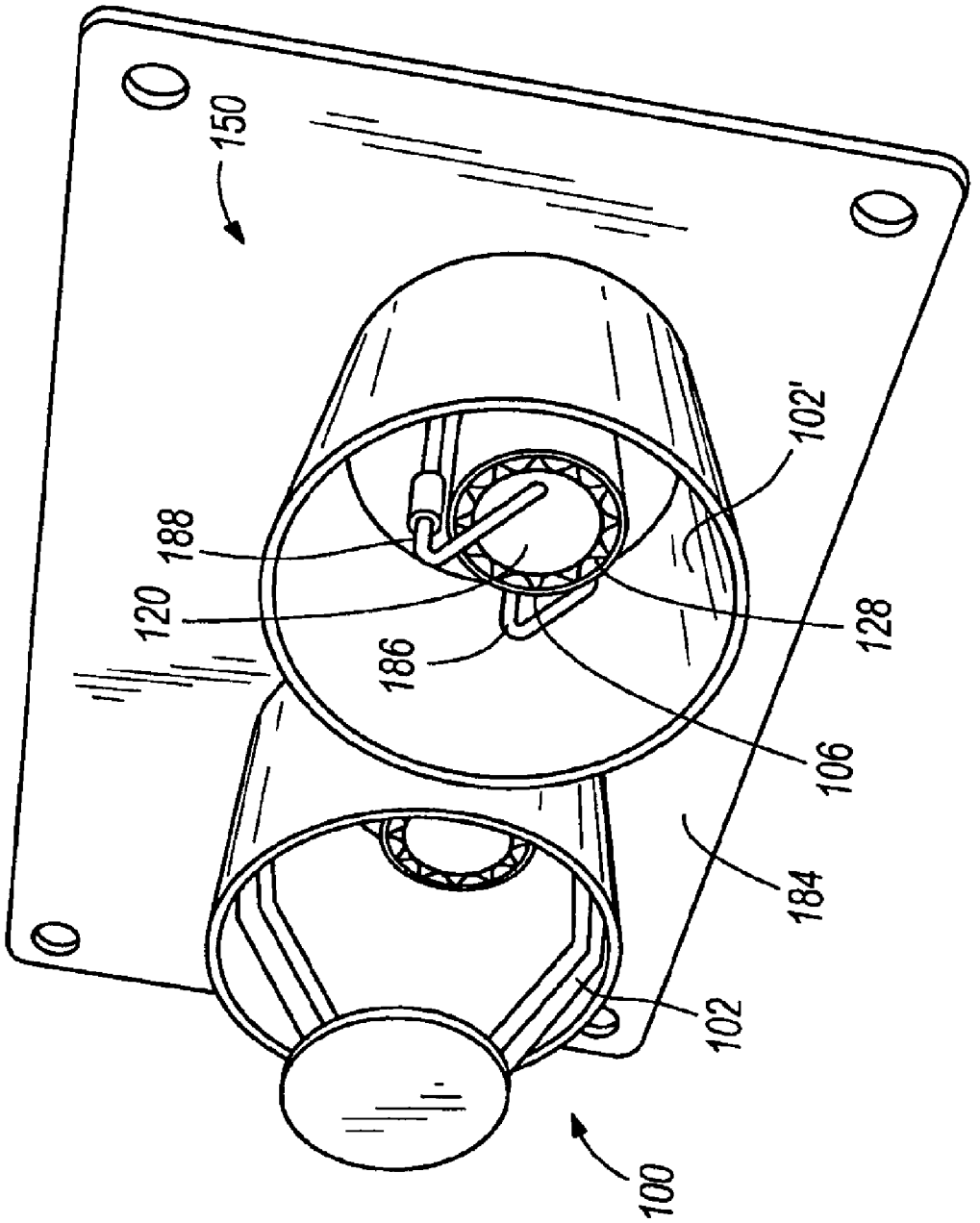

FIG. 8

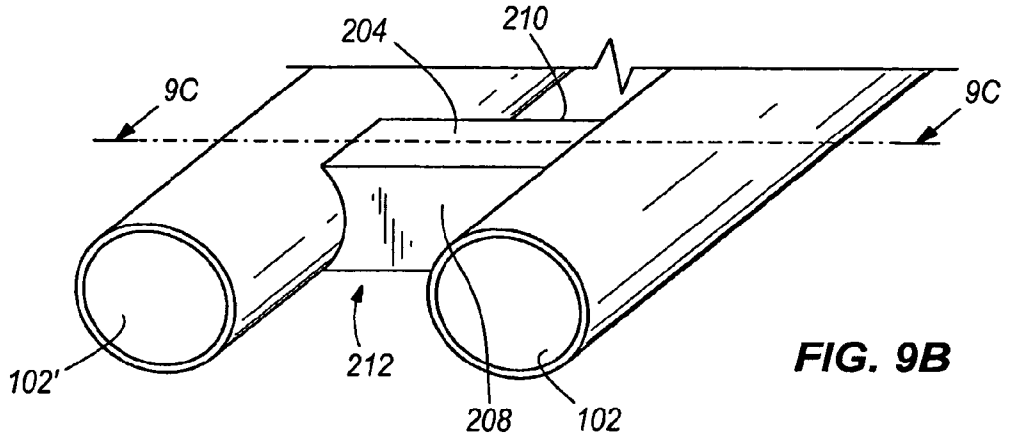

FIG. 9B

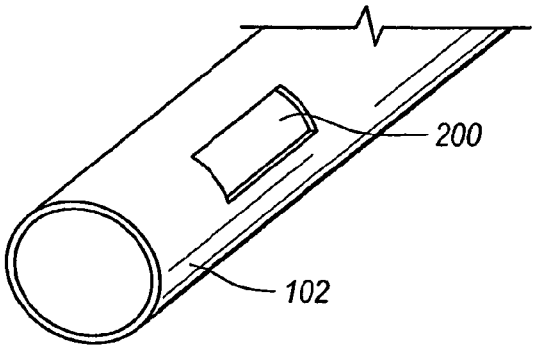

FIG. 9A

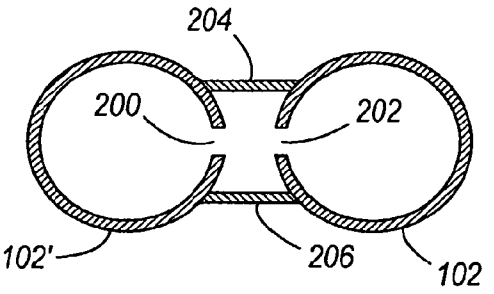

FIG. 9C

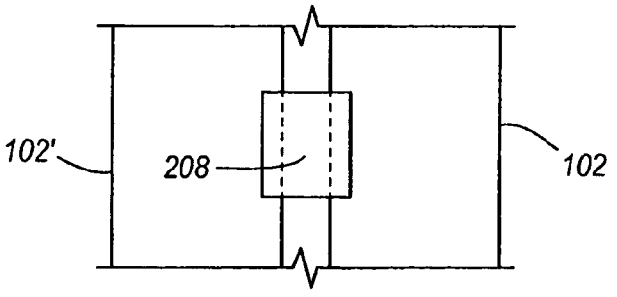

FIG. 9D

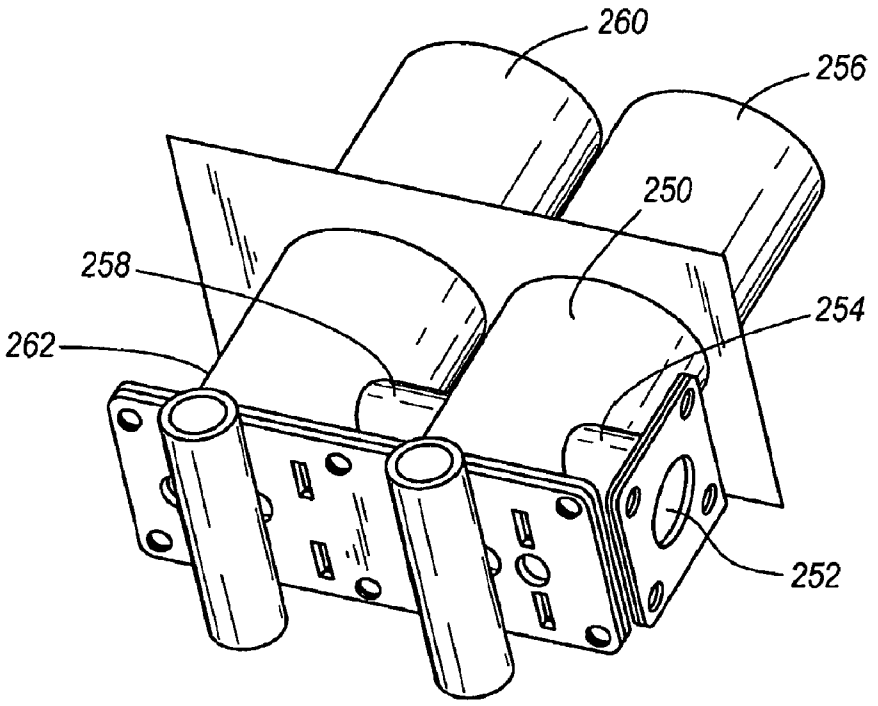
260
256
250
258
254
262
252

FIG. 10

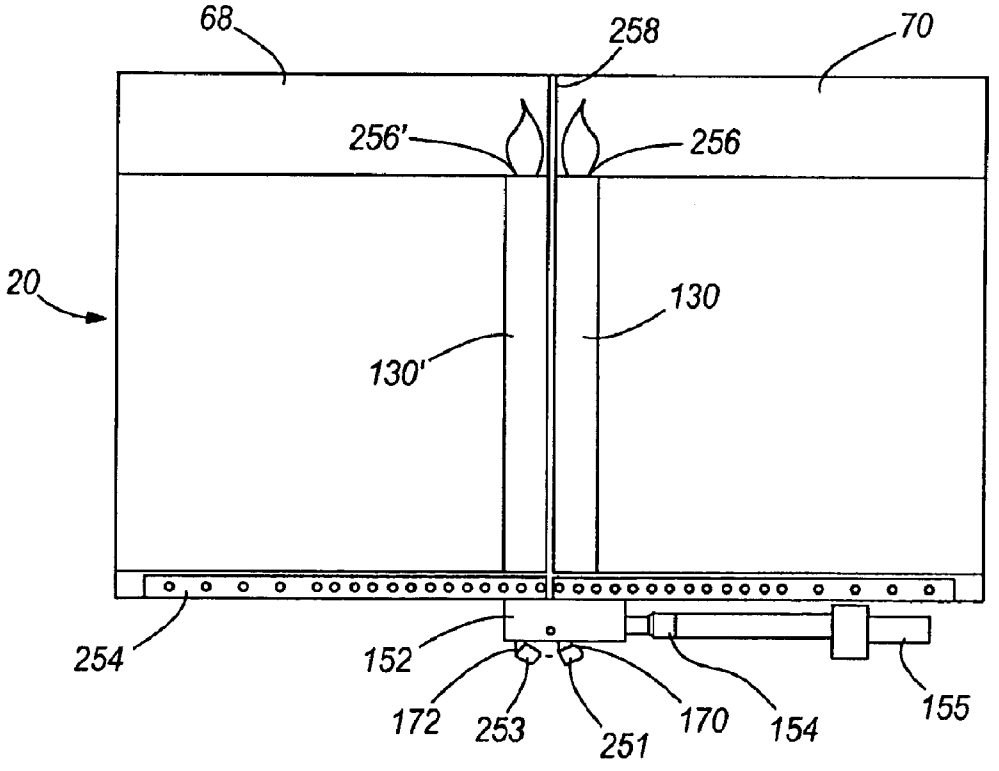
68
258
70
256'
256
20
130
130'
254
152
172
253
251
170
154
155

FIG. 11

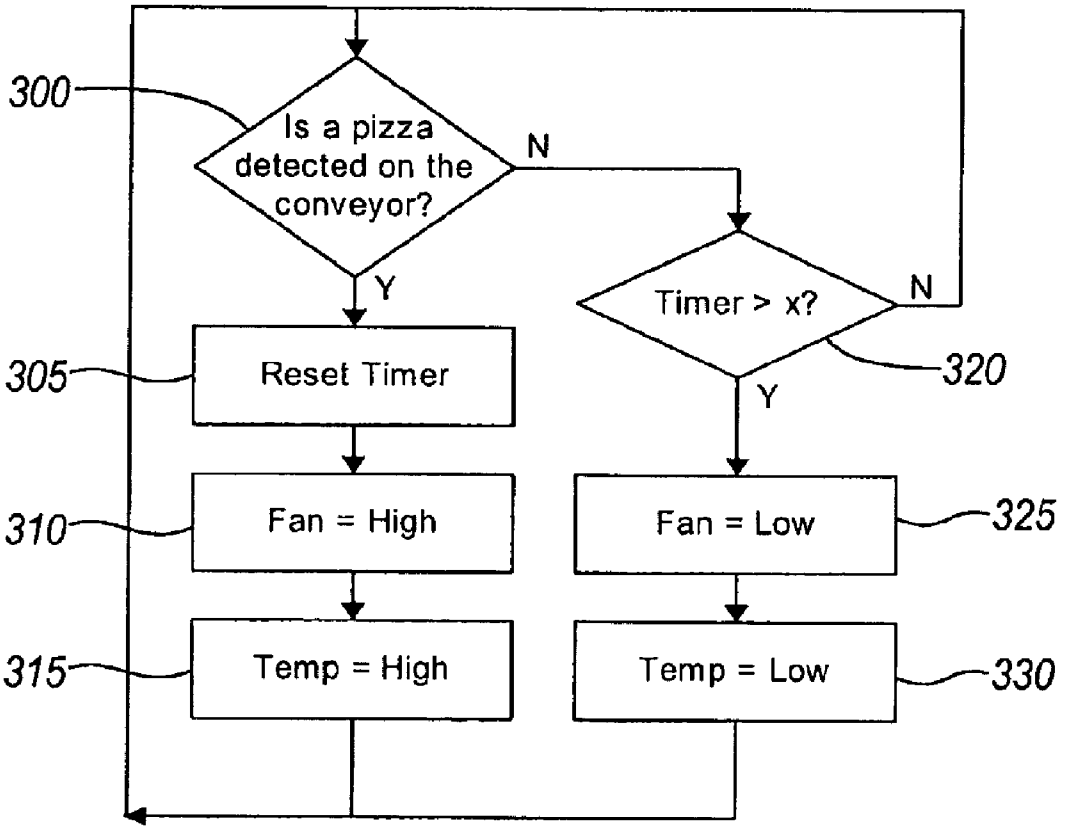
300
Is a pizza detected on the conveyor?
N
Y
Timer > x?
N
320
Y
305
Reset Timer
310
Fan = High
Fan = Low
325
315
Temp = High
Temp = Low
330

FIG. 12

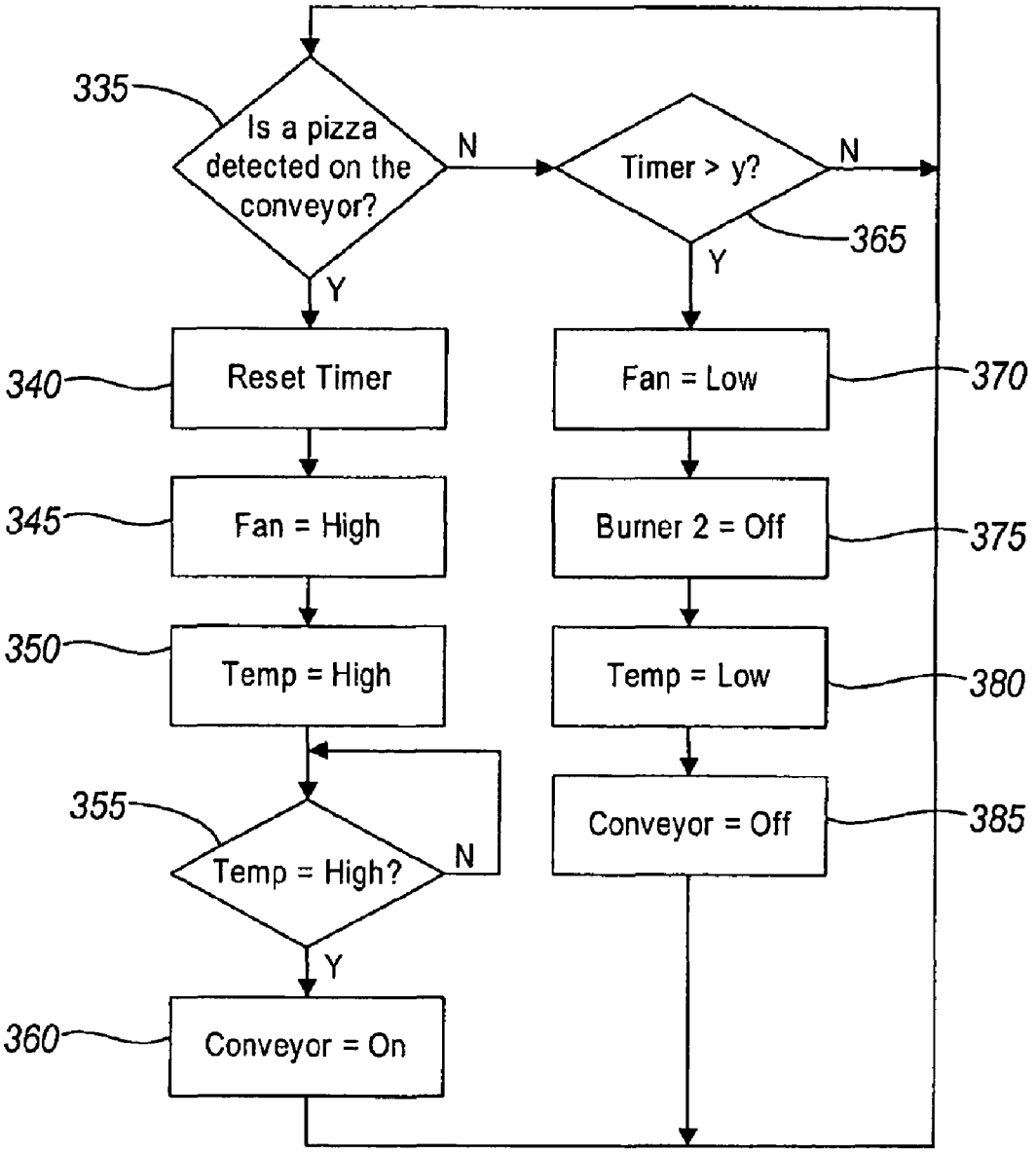
335
Is a pizza detected on the conveyor?
N
Timer > y?
N
365
Y
Y
340
Reset Timer
Fan = Low
370
345
Fan = High
Burner 2 = Off
375
350
Temp = High
Temp = Low
380
355
Temp = High?
N
Conveyor = Off
385
Y
360
Conveyor = On

FIG. 13

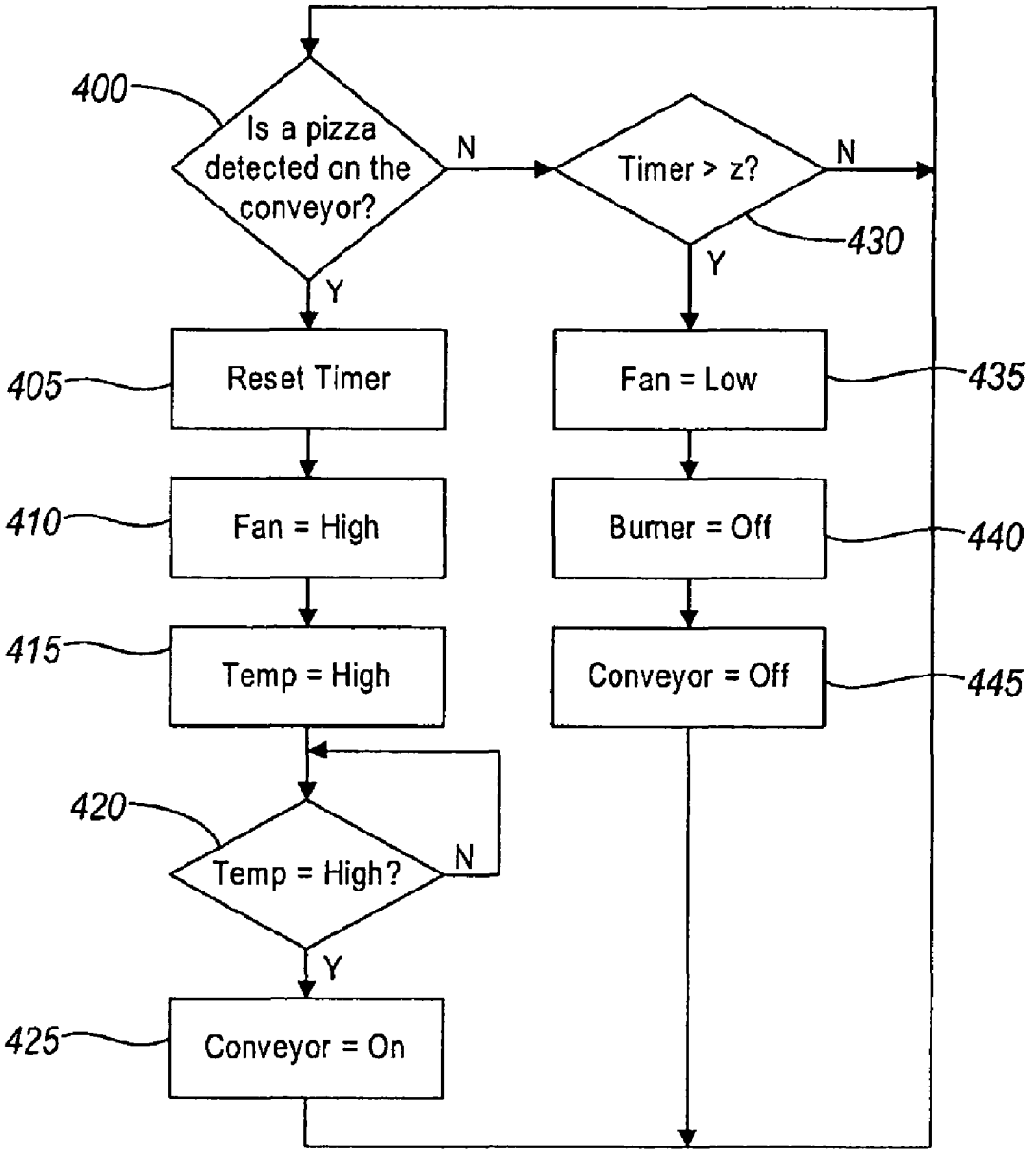
400
Is a pizza detected on the conveyor?
N
Timer > z?
N
430
Y
Y
405
Reset Timer
Fan = Low
435
410
Fan = High
Burner = Off
440
415
Temp = High
Conveyor = Off
445
420
Temp = High?
N
Y
425
Conveyor = On

FIG. 14

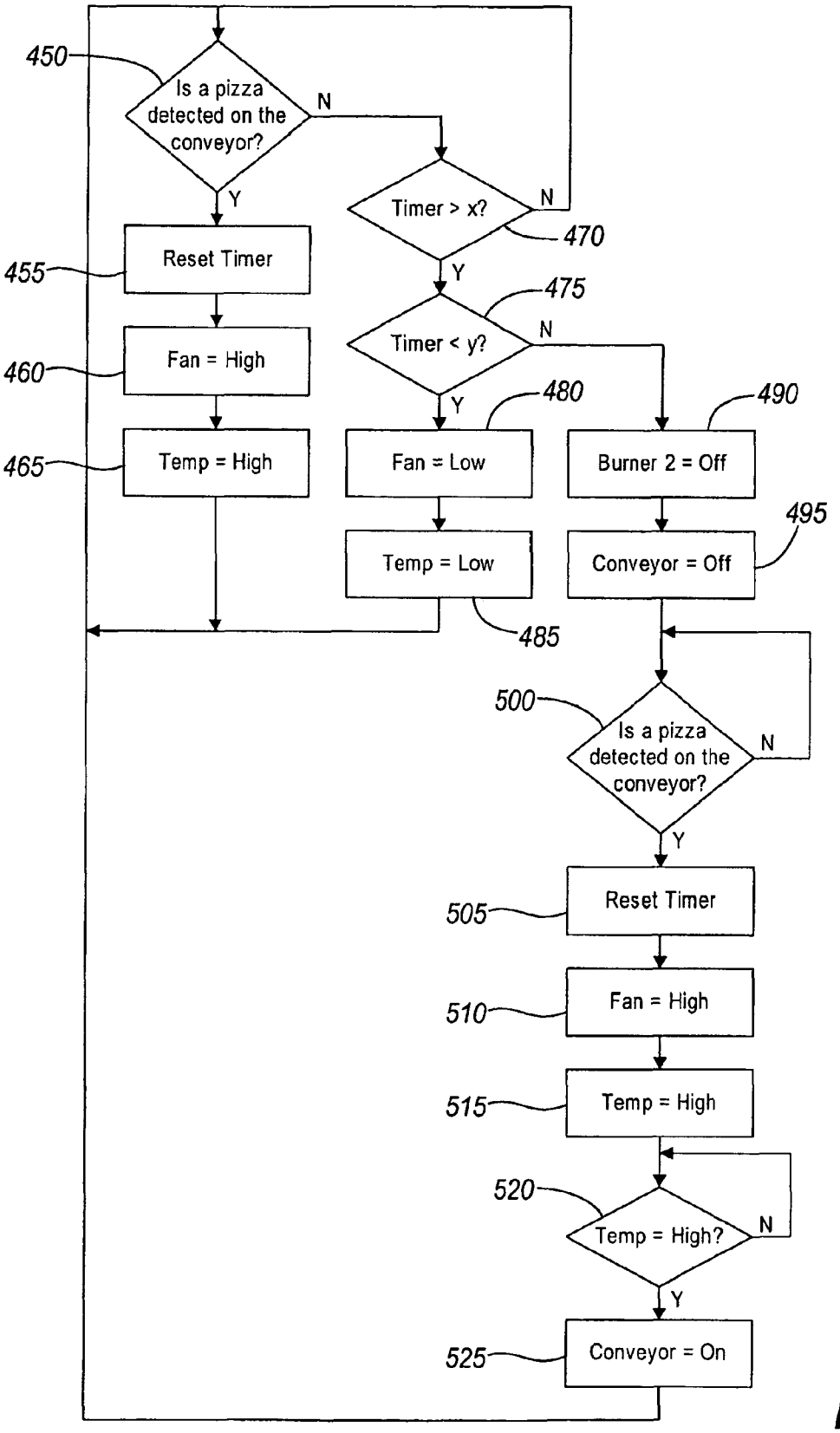
450
Is a pizza detected on the conveyor?
N
Y
Timer > x?
N
470
Y
455
Reset Timer
475
Timer < y?
N
460
Fan = High
Y
480
490
465
Temp = High
Fan = Low
Burner 2 = Off
495
Temp = Low
Conveyor = Off
485
500
Is a pizza detected on the conveyor?
N
Y
505
Reset Timer
510
Fan = High
515
Temp = High
520
Temp = High?
N
Y
525
Conveyor = On

FIG. 15

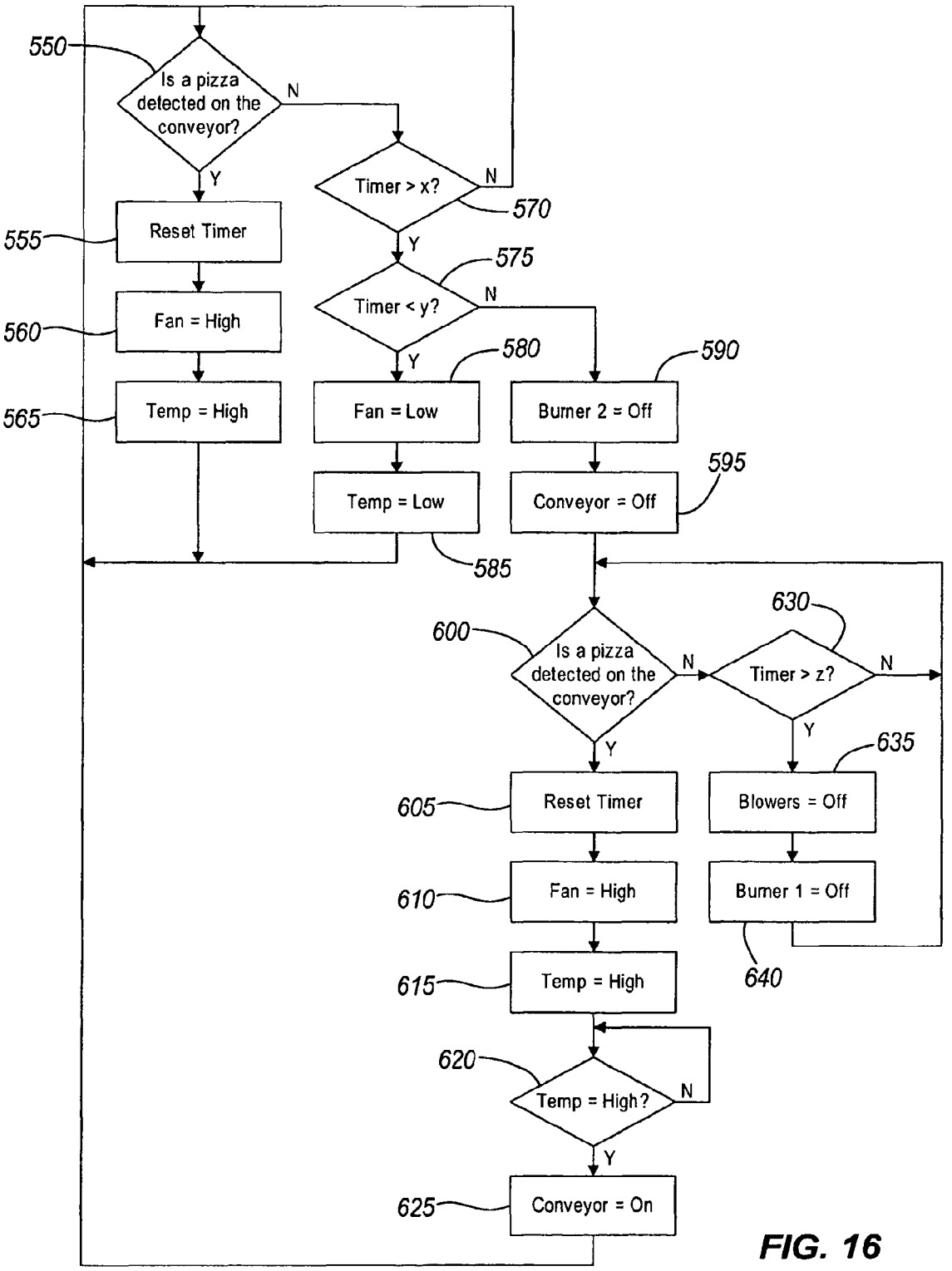
550
Is a pizza detected on the conveyor?
N
Y
Timer > x?
N
570
Y
555
Reset Timer
575
Timer < y?
N
560
Fan = High
Y
580
590
565
Temp = High
Fan = Low
Burner 2 = Off
595
Temp = Low
Conveyor = Off
585
630
600
Is a pizza detected on the conveyor?
N
Timer > z?
N
Y
Y
635
605
Reset Timer
Blowers = Off
610
Fan = High
Burner 1 = Off
640
615
Temp = High
620
Temp = High?
N
Y
625
Conveyor = On

FIG. 16

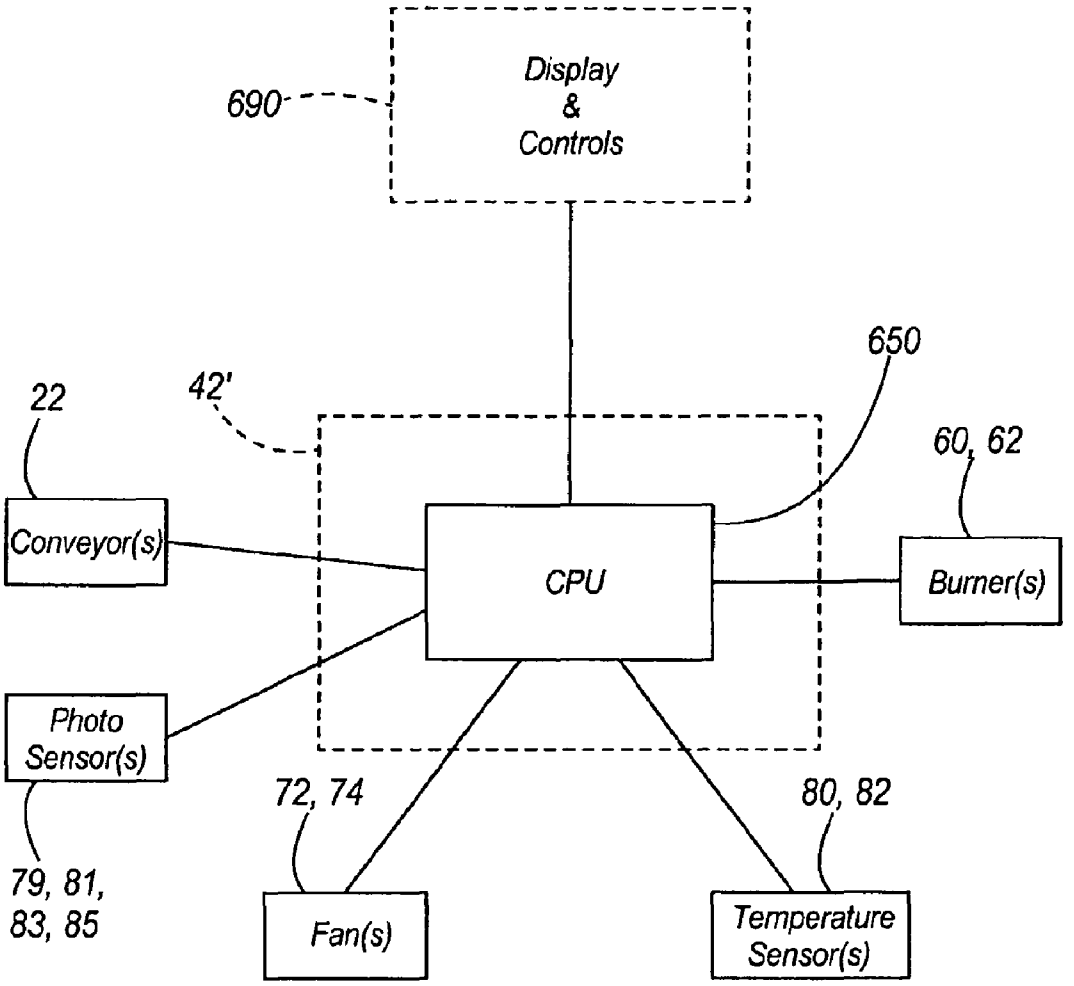
690
Display
&
Controls
650
22
42'
60, 62
Conveyor(s)
CPU
Burner(s)
Photo
Sensor(s)
72, 74
80, 82
79, 81,
83, 85
Fan(s)
Temperature
Sensor(s)

FIG. 17

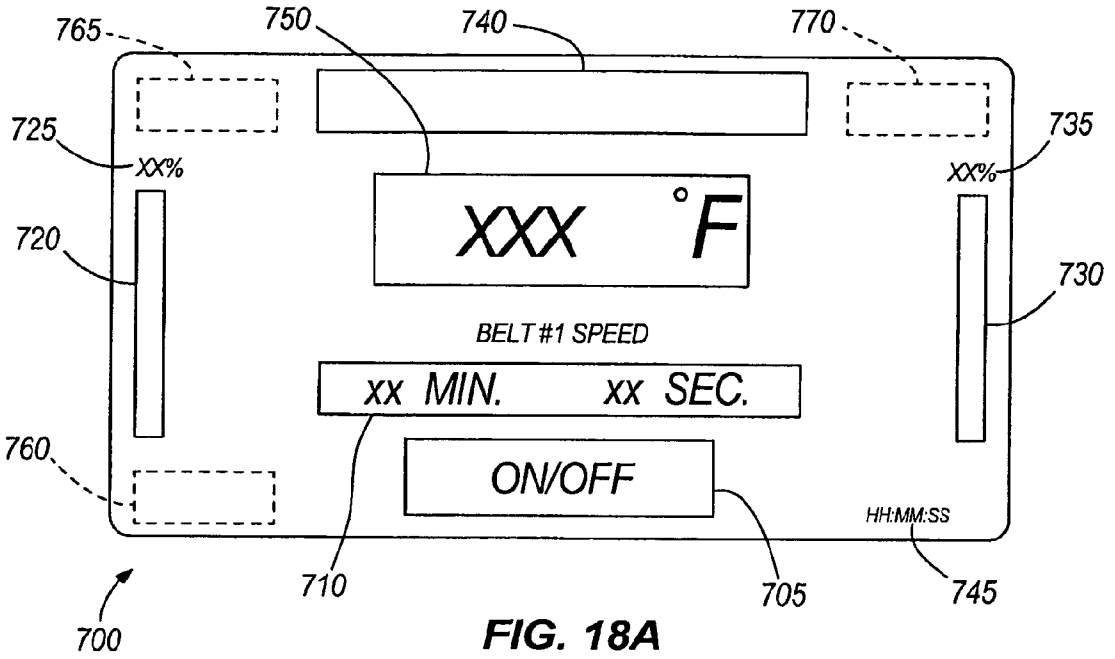

FIG. 18A

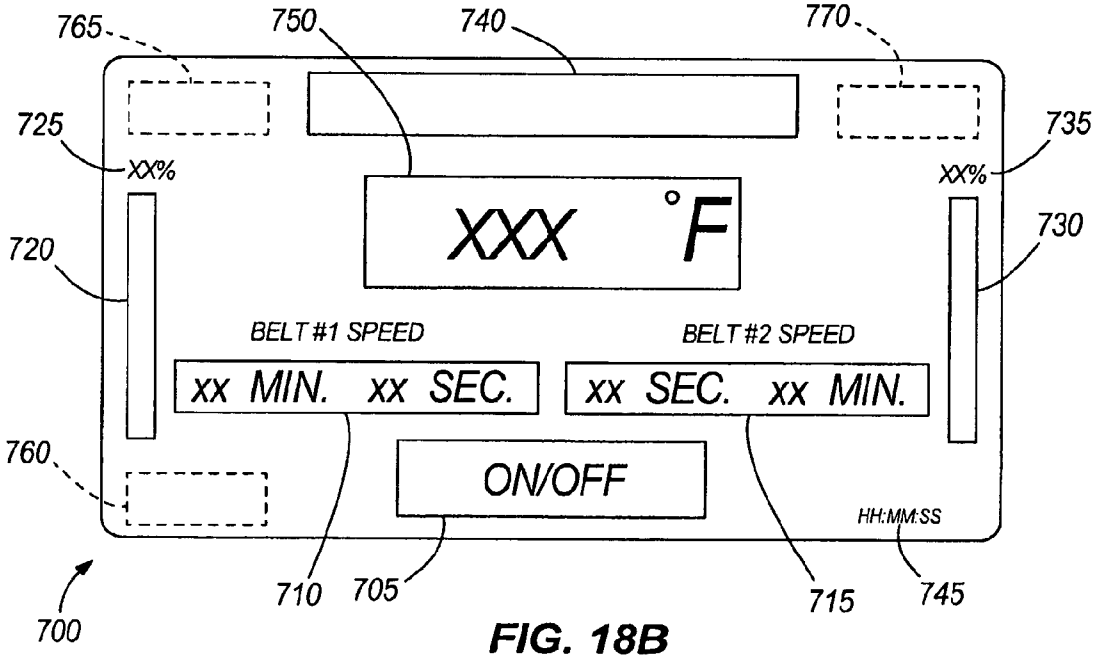

FIG. 18B

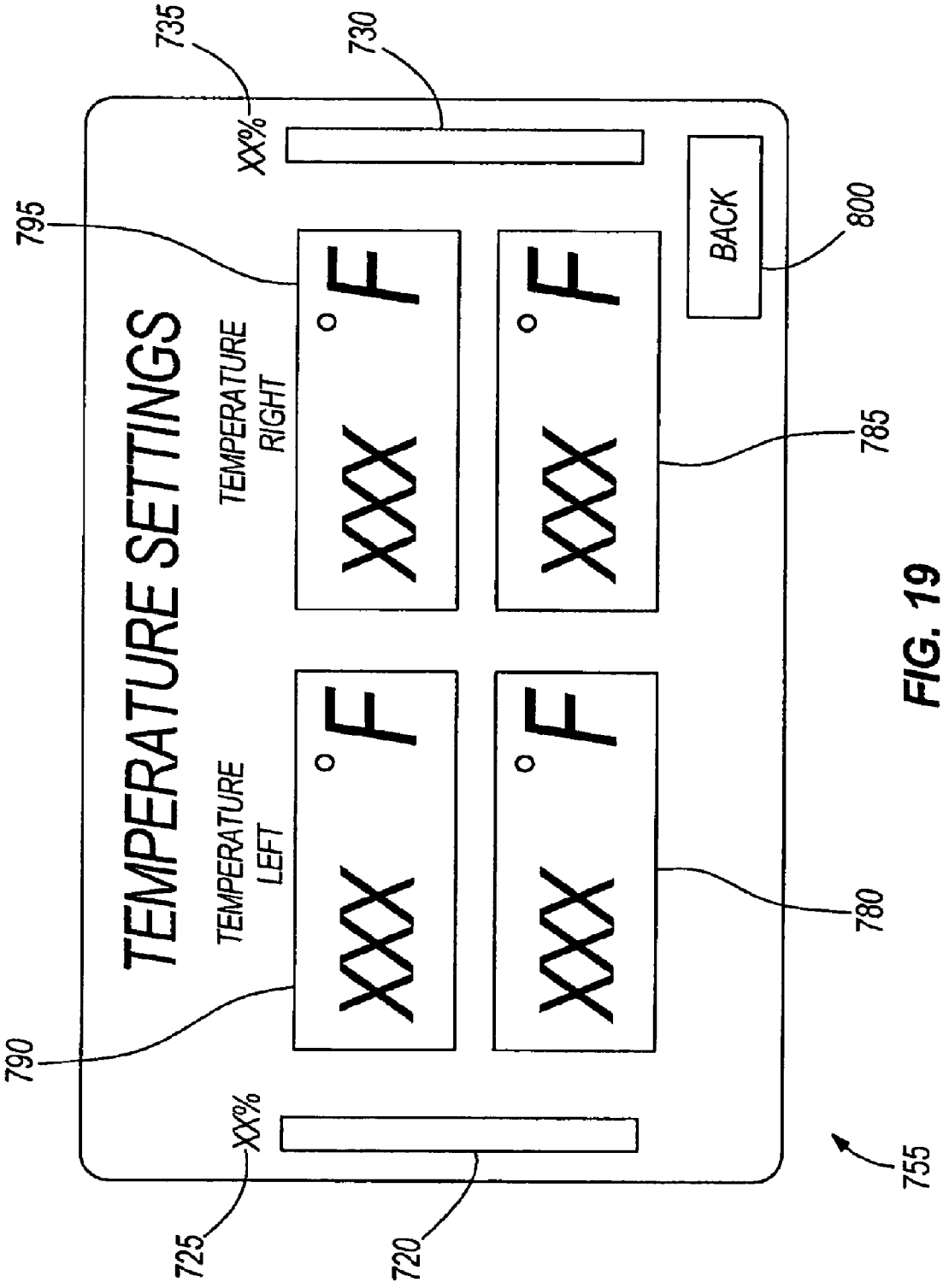
735
730
XX%
795
TEMPERATURE SETTINGS
TEMPERATURE RIGHT
XXX °F
XXX °F
BACK
800
785
TEMPERATURE LEFT
XXX °F
XXX °F
780
790
XX%
725
720
755

FIG. 19

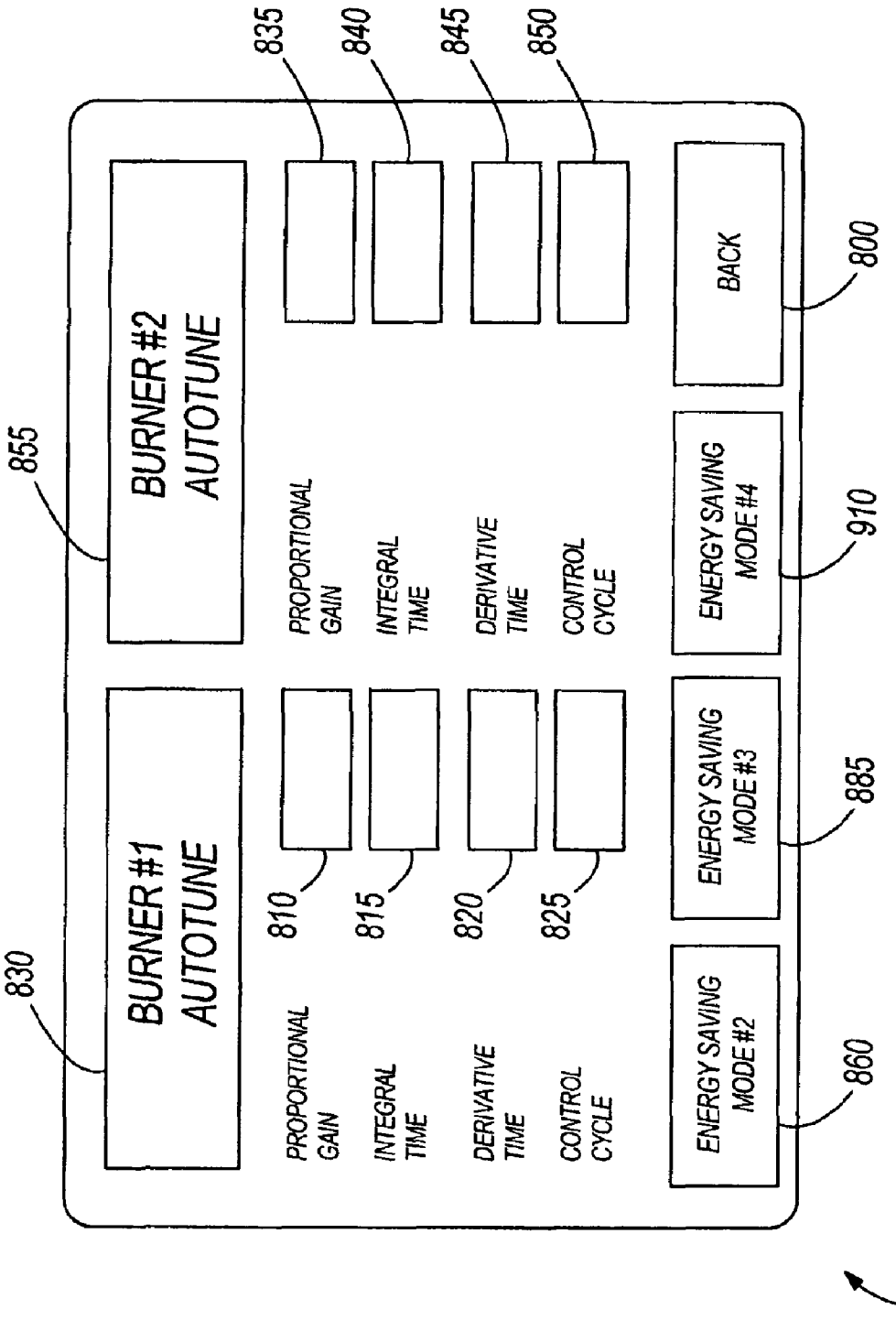
775
830
BURNER #1 AUTOTUNE
PROPORTIONAL GAIN
INTEGRAL TIME
DERIVATIVE TIME
CONTROL CYCLE
810
815
820
825
855
BURNER #2 AUTOTUNE
PROPORTIONAL GAIN
INTEGRAL TIME
DERIVATIVE TIME
CONTROL CYCLE
835
840
845
850
ENERGY SAVING MODE #2
860
ENERGY SAVING MODE #3
885
ENERGY SAVING MODE #4
910
BACK
800

FIG. 20

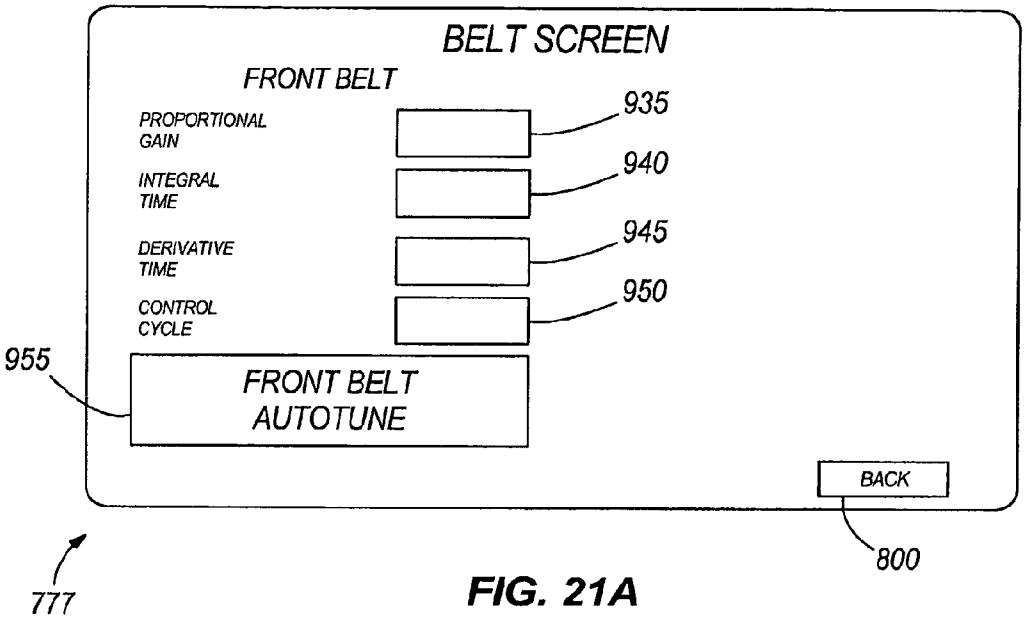

FIG. 21A

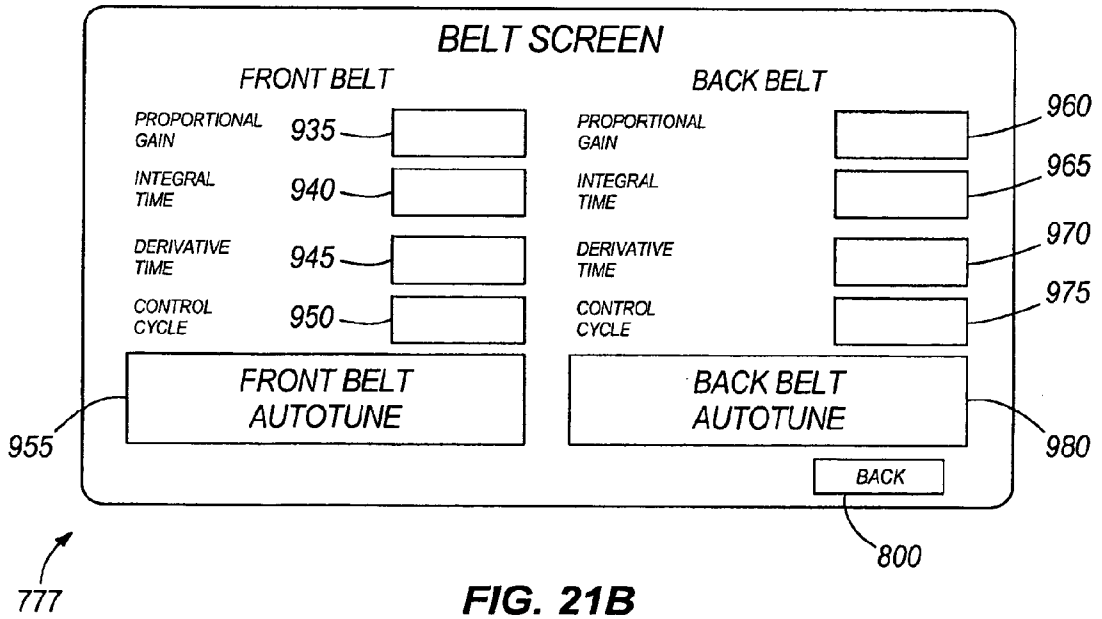

FIG. 21B

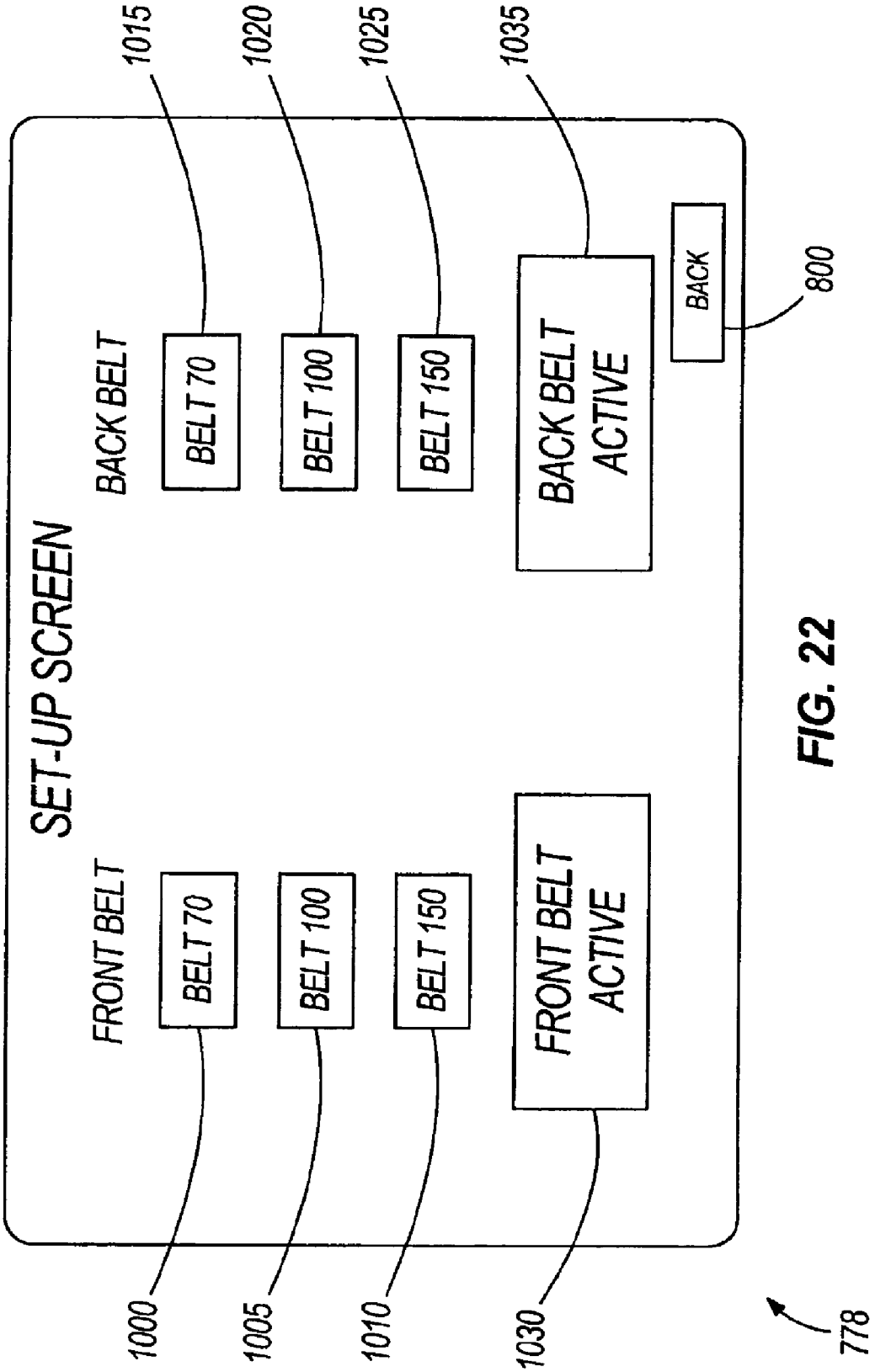
SET-UP SCREEN
FRONT BELT
BELT 70
BELT 100
BELT 150
FRONT BELT ACTIVE
BACK BELT
BELT 70
BELT 100
BELT 150
BACK BELT ACTIVE
BACK
800
1000
1005
1010
1030
1015
1020
1025
1035
778

FIG. 22

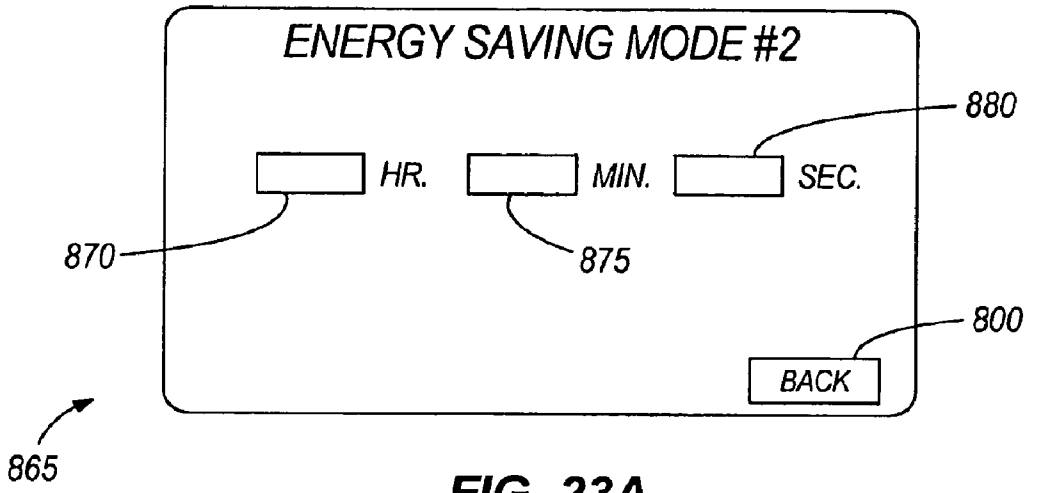

FIG. 23A

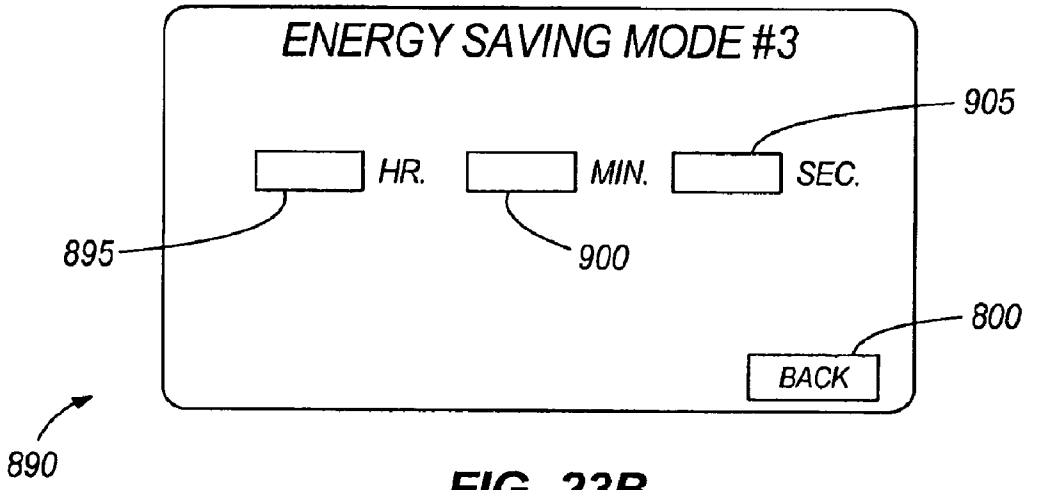

FIG. 23B

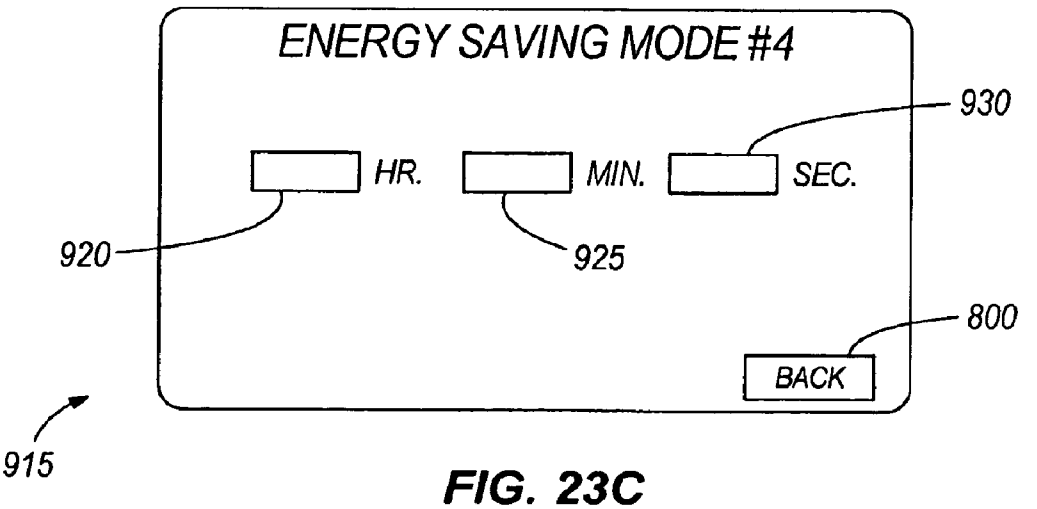

FIG. 23C

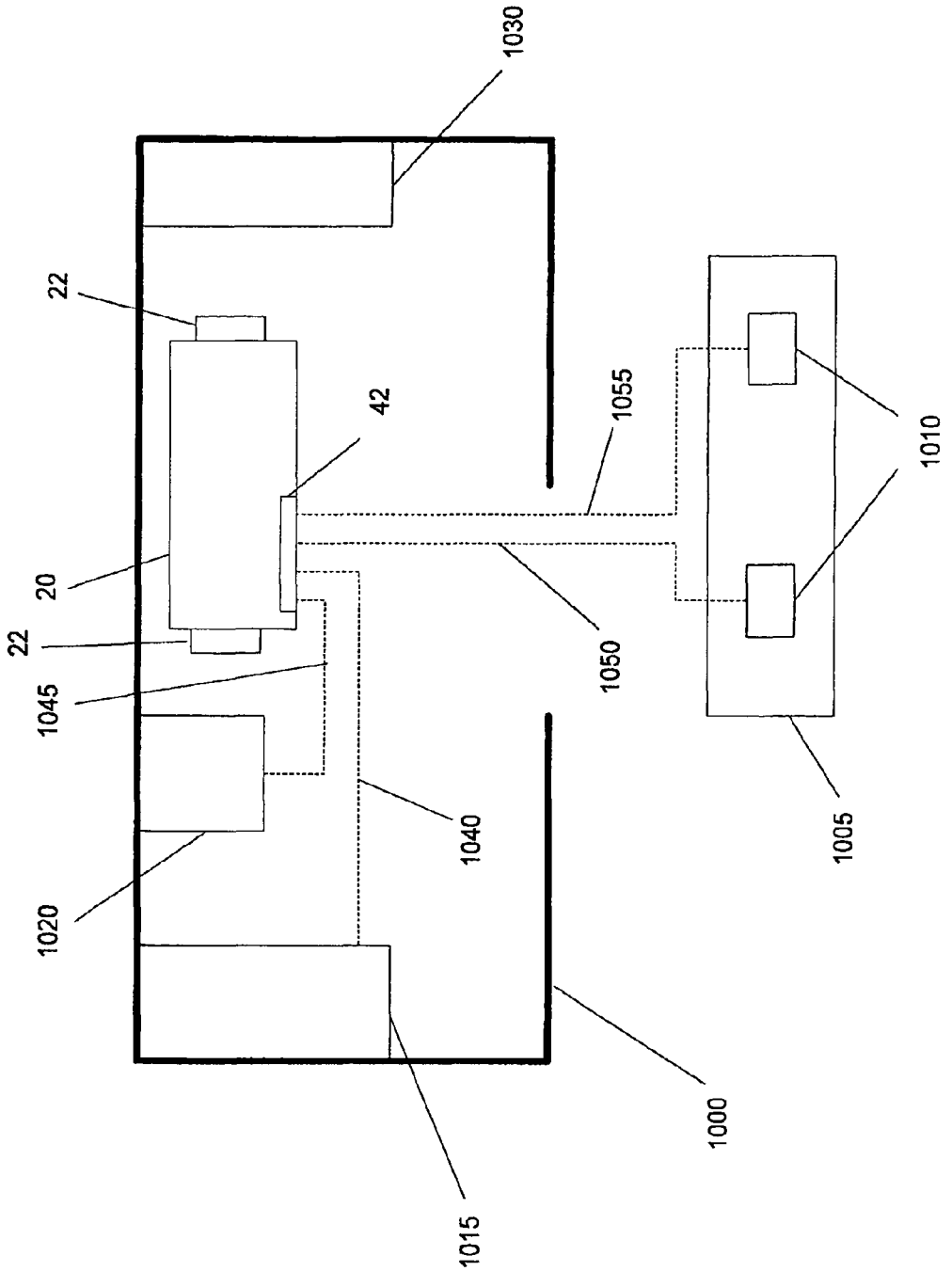

Fig. 24

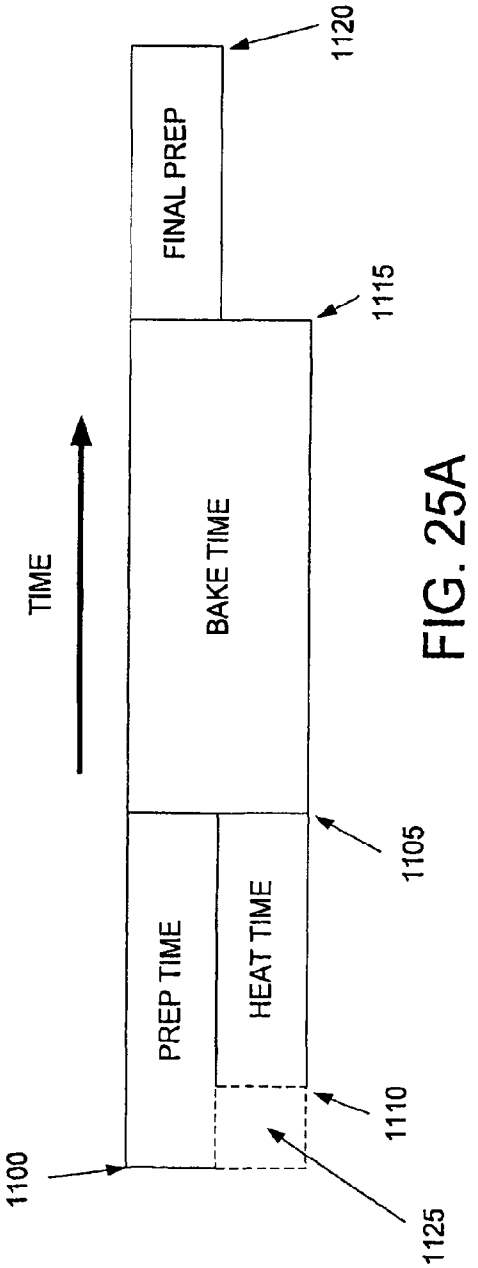

FIG. 25A

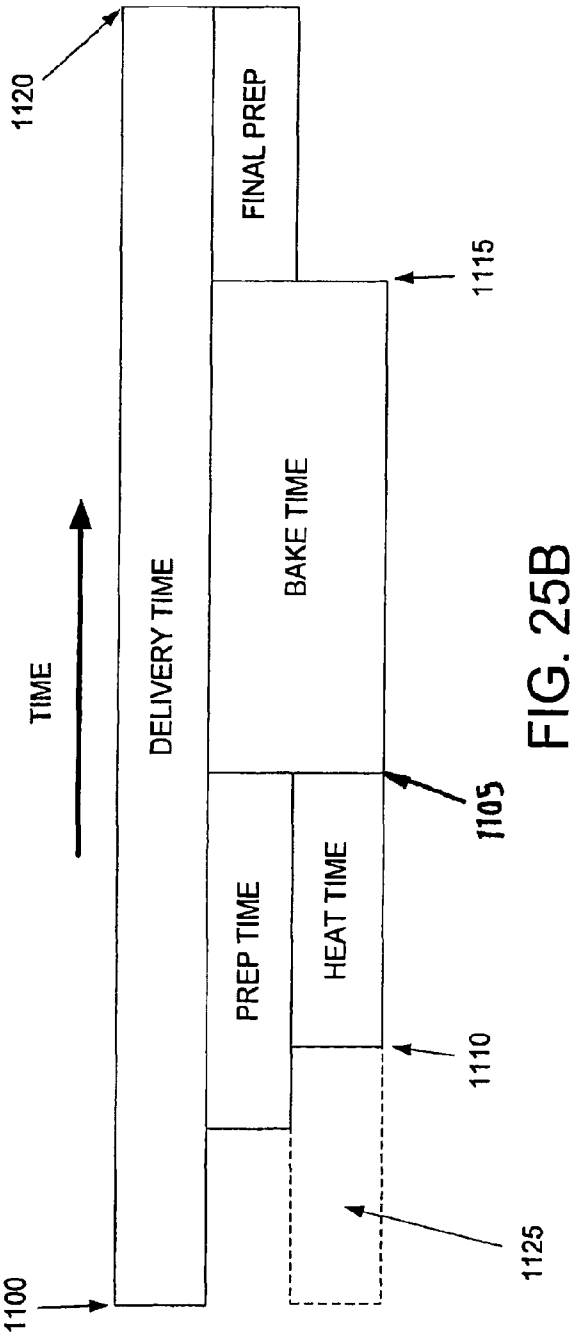

FIG. 25B

CONVEYOR OVEN APPARATUS AND METHOD

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation of U.S. patent application Ser. No. 11/526,133 filed Sep. 22, 2006, which is a continuation of International Patent Application Number PCT/US2006/022304 filed Jun. 8, 2006. U.S. patent application Ser. No. 11/526,133 is also a continuation-in-part of International Patent Application Number PCT/US2005/038783 filed Oct. 27, 2005, and is also a continuation-in-part of International Patent Application Number PCT/US2005/009546 filed Mar. 23, 2005, which claims benefit of U.S. Provisional Patent Application 60/555,474 filed Mar. 23, 2004. U.S. patent application Ser. No. 11/526,133 published as U.S. Publication No. 2007/0012307 on Jan. 18, 2007; International Patent Application No. PCT/US2006/022304 published as International Publication No. WO 2007/050136 on May 3, 2007; International Patent Application No. PCT/US2005/038783 published as International Publication No. WO 2006/101531 on Sep. 28, 2006; International Patent Application No. PCT/US2005/009546 published as International Publication No. WO 2005/094647 on Oct. 13, 2005; and U.S. Provisional Patent Application No. 60/555,474 was filed Mar. 23, 2004. The entire contents of each of the foregoing applications and publications are incorporated herein by reference.

BACKGROUND OF THE INVENTION

A conveyor oven is an oven with a conveyor that moves through a heated tunnel in the oven. Conveyor ovens are widely used for baking food products, especially pizzas, and the like. Examples of such ovens are shown, for example, in U.S. Pat. Nos. 5,277,105, 6,481,433 and 6,655,373.

Conveyor ovens are typically large metallic housings with a heated tunnel extending through them and a conveyor running through the tunnel. Usually such conveyor ovens are either 70 inches or 55 inches long, although they may be constructed in any suitable size. The conveyor transports food products through the heated oven tunnel at a speed which bakes food products during their transit through the tunnel. The conveyor ovens include a heat delivery system including blowers which supply heat to the tunnel from a plenum through passageways leading to metal fingers opening into the oven tunnel, at locations above and below the conveyor. The metal fingers act as airflow channels that deliver streams of hot air which impinge upon the surfaces of the food products passing through the tunnel on the conveyor. In modern conveyor ovens, a microprocessor-driven control panel generally enables the user to regulate the heat, the speed of the conveyor, etc., to properly bake the food product being transported through the oven.

The conveyor generally travels at a speed calculated to properly bake food products on the belt during the time period required for the conveyor to carry them through the entire length of the oven tunnel. Other food products requiring less time to bake may be placed on the conveyor at a point part way through the oven so that they travel only a portion of the length of the tunnel. A pizza is an example of a product which might require the full amount of baking time in order to be completely baked in the oven. A sandwich is an example of a product which might require only a portion of the full baking time.

Conveyor ovens are typically used in restaurant kitchens and commercial food manufacturing facilities. Typically they are kept running for extended periods of time, including periods when products are not being baked. Since the inlet and outlet ends of the oven are open, this means that heat and noise are continuously escaping from the conveyor oven tunnel into the surrounding environment. This escape of heat wastes energy. It also warms the surrounding environment, usually unnecessarily and often to uncomfortable levels. This is particularly the case where the conveyor oven is being used in relatively cramped restaurant kitchen environments. The escaping noise is also undesirable since it may interfere with interpersonal communication among those working near the oven.

Conventional conveyor ovens also provide users with limited ability to reduce energy losses while running at less than full capacity. Typically, users only have the ability to turn such ovens on or off, which in many cases involves an unacceptably long shut-down and/or start-up times. Therefore, it is necessary to leave such ovens on despite the waste of fuel or other energy supplied to the ovens when cooking food intermittently. It is not uncommon for a conventional conveyor oven to be left running in a full production mode for substantially the entire period of time a restaurant or other cooking facility is open.

It is generally desirable to maintain uniform heating from one end of the heated tunnel of the oven to the other. Among the challenges to be overcome in achieving such uniform heating are the inherent variations in heating from oven to oven due to variations in the internal physical environment of otherwise identical ovens. A more significant challenge to maintaining uniform heating through the length of the heated tunnel is the constantly changing physical and thermal configuration of the tunnel as food products being baked pass from one end of the tunnel to the other. For example, raw pizzas entering the inlet to the tunnel constantly change the physical and thermal configuration of the tunnel environment as they advance to the other end while drawing and emitting ever-varying amounts of heat. As a result, temperatures can vary by as much as 50-60° F. from one end of the tunnel to the other.

Currently, the most common technique for balancing the heating through the length of the tunnel involves monitoring temperatures near the inlet and outlet ends of the heated tunnel to maintain a predetermined average temperature over the length of the tunnel. Thus, for example, as a cold raw pizza enters the inlet to the tunnel causing a sudden drop in the tunnel temperature at the inlet, the drop in temperature is sensed and more heat is supplied to the tunnel to raise the temperature near the inlet heat sensor. Unfortunately, this also raises the temperature at the outlet of the oven, which causes the heat sensor at the outlet to trigger a heating reduction to prevent an excessive temperature at the oven outlet. In this way, temperature sensors near the inlet and outlet of the oven help to balance the heating of the tunnel to generally maintain a target average temperature.

However, uniform heating through the length of the heated tunnel cannot be achieved in this way. Thus, food products traveling through the oven do not see uniform heating which, it has been discovered, makes it necessary to slow the conveyor to a speed which completes the baking in more time than would be the case if uniform heating could be achieved throughout the length of the heated tunnel. In other words, improved heating uniformity from one end of the tunnel to the other may reduce required baking times.

Additionally, in many applications it is necessary to be able to operate the conveyor oven using either side as the inlet, by

running the conveyor belt either from left-to-right for a left side inlet, or from right-to-left for a right side inlet. To be most successful in such interchangeable applications, it is particularly desirable to produce a uniform temperature from one end of the heated tunnel to the other.

BRIEF SUMMARY OF THE INVENTION

Some embodiments of the present invention provide a conveyor oven for cooking food product, wherein the conveyor oven comprises a tunnel; a conveyor extending into and movable within the tunnel to convey food product within the tunnel; a heating element operable to generate heat to be provided to the tunnel; a fan operable to move air in the tunnel; a sensor positioned to detect at least one of a temperature within the oven and the presence of food product upon the conveyor; and a controller coupled to at least one of the fan, the heating element, and the conveyor to change operation of the at least one of the fan, heating element, and conveyor based at least in part upon passage of a period of time.

In some embodiments, a conveyor oven for cooking food product is provided, and comprises a tunnel; a conveyor extending into and movable within the tunnel to convey food product within the tunnel; a heating element operable to generate heat to be provided to the tunnel; a controller coupled to the heating element to control the heating element; a user interface coupled to the controller, the user interface comprising a touch screen; and a plurality of displays adapted to be displayed upon the touch screen, each of the plurality of displays having at least one user-manipulatable control to receive user commands via the touch screen, wherein at least one of the displays is accessed and displayed upon the touch screen by a user manipulatable control on another of the plurality of displays.

Some embodiments of the present invention provide a conveyor oven for cooking food product, wherein the conveyor oven comprises a tunnel; a conveyor extending into and movable within the tunnel to convey food product within the tunnel; a heating element operable to generate heat to be provided to the tunnel; a controller coupled to the heating element to control the heating element; a user interface coupled to the controller, the user interface comprising a touch screen; and a first display adapted to be displayed upon the touch screen, the first display having at least one user-manipulatable control to receive commands from a first user to operate the conveyor oven; and a second display adapted to be displayed upon the touch screen, the second display having at least one user-manipulatable control to receive commands from a second user to configure the conveyor oven, the second display readily accessible by the second user but not by the first user.

In some embodiments, an oven for cooking food product is provided, and comprises an oven chamber in which food is cooked; a heating element operable to generate heat to be provided to the oven chamber; a fan operable to move air in the oven chamber; a sensor positioned to detect at least one of a temperature within the oven chamber and the presence of food product; a remote input device; and a controller configured to receive a signal from the remote input device, the controller coupled to at least one of the fan and the heating element, and adapted to change operation of the at least one of the fan and the heating element based at least in part upon the signal from the remote input device.

Some embodiments of the present invention provide an conveyor oven for cooking food product passing through the conveyor, wherein the conveyor oven comprises a tunnel within which food product is cooked; a conveyor movable to convey food product through the tunnel; a heating element operable to generate heat to be provided to the tunnel; a fan operable to move air in the tunnel; a remote input device by which data reflecting a quantity of food product to be cooked is received; and a controller configured to receive a signal from the remote input device, the controller coupled to at least one of the fan and the heating element, and adapted to automatically change operation of the at least one of the fan and the heating element based at least in part upon the signal from the remote input device.

In some embodiments, a method of operating an oven for cooking food product is provided, and comprises entering an energy saving mode via a controller; receiving a signal representative of an order for cooked food product from a remote device in communication with the controller; and automatically entering an operating mode via the controller responsive to receiving the signal representative of an order for cooked food product, wherein energy consumption by the oven is substantially lower in the energy saving mode than in the operating mode.

Further aspects of the present invention, together with the organization and operation thereof, will become apparent from the following detailed description of the invention when taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Preferred embodiments of the invention are shown in the attached drawings, in which:

FIG. **1** is a perspective view of a conveyor oven in accordance with an embodiment of the present invention;

FIG. **2** is a perspective view of a portion of the conveyor oven of FIG. **1**, in which a hinged oven access panel has been opened to reveal some of the internal workings of the oven;

FIG. **3** is an enlarged elevation view of an embodiment of the controls of the oven of FIG. **1**;

FIG. **3**A is a schematic illustration of an embodiment of the control system of the conveyor oven of FIG. **1**;

FIG. **4** is a diagrammatic representation of the tunnel of the oven of FIG. **1**, apportioned into two segments with independent temperature sensing and independent heat delivery means;

FIGS. **5**A-**5**C include a diagrammatic representation of a pizza moving through the heated tunnel of the conveyor oven of FIG. **1**, with graphs showing changing BTU burner output and blower output as the pizza advances through the tunnel;

FIG. **6** is a diagrammatic representation of a single burner of a contiguous multiple burner configuration in accordance with an embodiment of the present invention;

FIG. **6**A illustrates a venturi support disk of the burner of FIG. **6**;

FIG. **6**B illustrates a flame retention member of the venturi tube of the burner of FIG. **6**;

FIGS. **7**A and **7**B are perspective views of a pair of contiguous burners in accordance with an embodiment of the present invention;

FIG. **8** shows the distal ends of the outer tubes of the burners of FIGS. **7**A-**7**B;

FIGS. **9**A-**9**D illustrate crossover openings between the contiguous burners of FIGS. **7**A-**7**B;

FIG. **10** illustrates an alternative dual contiguous burner configuration in accordance with an embodiment the present invention; and

FIG. **11** is a top plan view of selected elements of the oven of FIG. **1**.

FIG. **12** is a flowchart illustrating an energy management mode for the conveyor oven of FIG. **1**.

FIG. **13** is a flowchart illustrating an energy management mode for the conveyor oven of FIG. **1**.

FIG. **14** is a flowchart illustrating an energy management mode for the conveyor oven of FIG. **1**.

FIG. **15** is a flowchart illustrating a combination of the energy management modes illustrated in FIGS. **12** and **13** for the conveyor oven of FIG. **1**.

FIG. **16** is a flowchart illustrating a combination of the energy management modes illustrated in FIGS. **12**, **13**, and **14** for the conveyor oven of FIG. **1**.

FIG. **17** is a schematic illustration of an alternative embodiment of the control system of the conveyor oven of FIG. **1**.

FIG. **18**A illustrates an embodiment of a main screen of an operator interface for the control system illustrated in FIG. **17**.

FIG. **18**B illustrates another embodiment of a main screen of an operator interface for the control system illustrated in FIG. **17**.

FIG. **19** illustrates an embodiment of a temperature setting screen of an operator interface for the control system illustrated in FIG. **17**.

FIG. **20** illustrates an embodiment of a temperature tuning screen of an operator interface for the control system illustrated in FIG. **17**.

FIG. **21**A illustrates an embodiment of a belt tuning screen of an operator interface for the control system illustrated in FIG. **17**.

FIG. **21**B illustrates another embodiment of a belt tuning screen of an operator interface for the control system illustrated in FIG. **17**.

FIG. **22** illustrates an embodiment of a belt set-up screen of an operator interface for the control system illustrated in FIG. **17**.

FIGS. **23**A, **23**B, and **23**C illustrate an embodiment of energy savings mode set-up screens of an operator interface for the control system illustrated in FIG. **17**.

FIG. **24** is an example of a food service floor plan showing a controller for a conveyor oven connected to several remote devices.

FIGS. **25**A and B are examples of time lines of conveyor oven operation based on indications from one or more remote devices.

DETAILED DESCRIPTION

Before any embodiments of the invention are explained in detail, it is to be understood that the invention is not limited in its application to the details of construction and the arrangement of components set forth in the following description or illustrated in the following drawings. The invention is capable of other embodiments and of being practiced or of being carried out in various ways. Also, it is to be understood that the phraseology and terminology used herein is for the purpose of description and should not be regarded as limiting. The use of "including," "comprising," or "having" and variations thereof herein is meant to encompass the items listed thereafter and equivalents thereof as well as additional items. Unless limited otherwise, the terms "connected," "coupled," and "mounted" and variations thereof herein are used broadly and encompass direct and indirect connections, couplings, and mountings, and the terms "connected" and "coupled" and variations thereof are not restricted to physical or mechanical connections or couplings. Also, it is to be understood that phraseology and terminology used herein with reference to device or element orientation (such as, for example, terms like "front", "back", "up", "down", "top", "bottom", and the like) are only used to simplify description of the present invention, and do not alone indicate or imply that the device or element referred to must have a particular orientation. In addition, terms such as "first", "second", and "third" are used herein and in the appended claims for purposes of description and are not intended to indicate or imply relative importance or significance.

Conveyors

FIG. **1** shows a conveyor oven **20** having a conveyor **22** which runs through a heated tunnel **24** of the oven. The conveyor **22** has a width generally corresponding to the width of the heated tunnel **24** and is designed to travel in direction A from left oven end **26** toward right oven end **28** or, alternatively in direction B, from right oven end **28** toward left oven end **26**. Thus, oven ends **26** and **28** may serve respectively as the inlet and outlet of an oven with a rightwardly moving conveyor or as the outlet and inlet of an oven with a leftwardly moving conveyor.

The support, tracking and drive of conveyor **22** are achieved using conventional techniques such as those described in U.S. Pat. Nos. 5,277,105 and 6,481,433 and 6,655,373, the contents of which are incorporated herein by reference insofar as they relate to conveyor support, tracking, and drive systems and related methods. In the illustrated embodiment, a chain link drive is housed within compartment **30** at the left end **26** of the oven. Thus, a food product, such as a raw pizza **32**R, may be placed on the conveyor **22** of the ingoing left oven end **26** and removed from the conveyor **22** as fully baked pizza **32**C (see FIG. **5**C) at the outgoing right oven end **28**. The speed at which the conveyor **22** moves is coordinated with the temperature in the heated tunnel **24** so that the emerging fully cooked pizza **32**C is properly baked.

Normally only one conveyor is used, as shown. However, certain specialized applications may make two or more conveyors a preferable design. For example, a first conveyor may begin at left oven end **26** and travel at one speed to the center or other location of the oven **20**, while a second conveyor beginning at such a location and ending at the right oven end **28** may travel at a different speed. Alternatively, conveyors that are split longitudinally may be used, so that one conveyor carries a product in direction A while the other conveyor carries a product in direction B, or so that two side-by-side conveyors carry product in parallel paths and in the same direction (A or B) through the oven **20**. This enables one product to travel on the conveyor at one speed to bake one kind of product and the other conveyor to travel on the other conveyor at a different speed to bake another kind of product. In addition, three or more side-by-side conveyors can carry product in parallel paths through the oven **20**.

Access

With reference to FIG. **1**, a hinged door **34** is provided on the front of the oven **20**, with a heat resistant glass panel **36** and a handle **35** so that a person operating the oven can view food product as it travels through the oven **20**. A stainless steel metal frame surrounds the oven opening and provides a support for a gasket of suitable material (not shown), so that when the door **34** is in its closed position, it fits against and compresses the gasket to retain heat in the oven **20**. Also, the operator may open the door **34** by pulling on handle **35** to place a different product on the conveyor **22** if less than a full bake cycle is required to produce a fully cooked product.

A hinged oven access panel **38** is also provided, open as shown in FIG. **2**, to expose inner workings and controls of the oven **20**. As explained in more detail below, in some embodi-

ments the hot air blowers and ducts, their associated components, and/or the temperature sensors of the oven **20** can be located within the area revealed by the opened access panel **38**.

Oven Controls

FIG. **3**A shows a schematic illustration of the control system for the oven **20**. A microprocessor-based controller **42** may include a central processing unit ("CPU") **650**, one or more displays **655**, and a control interface **660**. The CPU **650** can control a plurality of devices including one or more burners **60**, **62** (including one or more blower switches, ignition switches and blowers, fuel valves, and flame sensing elements), one or more fans **72**, **74** (described in greater detail below), and one or more conveyors **22**. The CPU **650** may also receive input from a plurality of sensors including one or more temperature sensors **80**, **82** and one or more photo sensors **79**, **81** and/or **83**, **85** (also described in greater detail below).

The oven controls, as shown in FIG. **3**B, can include the controller **42** (such as a Honeywell UDC **3300** controller) which may be programmed to control and monitor the baking process by pressing appropriate set-up and display buttons **44***a*-**44***h* while viewing alphanumeric display **46**, which will display process variables and setpoints including oven temperature, hot air blower speed, etc. A "heat on" indicator can be illuminated when a minimum threshold heat output is generated by the oven **20** under control of the controller **42**. The present temperature and/or the programmed setpoint temperature may be displayed. By simultaneously pressing selected keys in some embodiments, the value of the heat output with the heat on indicator in the "on" condition can be displayed. Also, the controller **42** can be configured to enable a user to cycle through actual temperature display indicators to reveal the actual temperatures, setpoint temperature, and the heat on condition. In the illustrated embodiment, the speed and direction of the conveyor **22** can be set using buttons **48***a*, **48***b*, **50***a* and **50***b* and their associated displays **48***c* and **50***c*.

In some embodiments, the output display **46** can be automatically locked in a default display when a service person or operator places the controller **42** in a service mode by pressing appropriate key(s). Also, a failsafe condition can occur when any one of various tests fail, at which time a signal display (e.g., one or more flashing indicators) can be displayed, such as a signal display flashing alternately with a temperature display. For example, if the oven **20** has not reached 200° F. within 15 minutes after an initial power-up of the oven **20**, a message can be flashed on the display panel **46** indicating that controls need to be reset (e.g., power-cycled). As another example, if a temperature sensor fails to operate properly, the display **46** can flash "open". Also, the display **46** can provide one or more prompts for servicing the oven **20**. Each additional press of a service tool key can advance so that a service person can continually sequence through service prompts of a service mode. The service mode can be exited, for example, by either pressing an appropriate key or by pressing no key for a set period of time (e.g., sixty seconds). In either case, the system can be automatically returned to a normal state.

In the illustrated embodiment, a setpoint lock key **42***d* can automatically flash the temperature that has been selected for an operation of the oven **20**. In some embodiments, this setpoint temperature can be increased or decreased by pressing either increment or decrement keys **42***f*, **42***g*. Also, in some embodiments the degrees (° F. or ° C.) used for the prompts can be changed by pressing either the increment or decrement keys **42***f*, **42***g*. While at a degrees ° F. or ° C. prompt, a selection of "F" or "C" can automatically change the units of all the display **46** to ° F. or ° C. While a default display prompt is being displayed, an indicator can flash to indicate which display is chosen as the default display, which can be changed, for example, by pressing either the increment or decrement keys **42***f*, **42***g*.

In some embodiments, the oven **20** is operated by: (1) turning a blower control **52** to an "ON" position to start a blower (described in greater detail below), (2) setting the temperature to a desired level using the controller **42** as described above, (3) turning a heat control **54** to an "ON" position to supply gas and to trigger ignition of the oven burner(s) (described in greater detail below), (4) turning a conveyor control **56** to an "ON" position to drive the conveyor **22**, and (5) after an appropriate pre-heat period, placing food products on the conveyor and beginning the baking process.

Tunnel Segments

Heat delivery systems for supplying heat to the tunnel **24** are described in U.S. Pat. Nos. 5,277,105, 6,481,433 and 6,655,373, the disclosures of which are incorporated herein by reference insofar as they relate to heat delivery systems for ovens. These systems typically include a heat source in the form of a single gas-fired burner (or other heat source) for heating a plenum. For example, the burner can be located at the front of the oven for heating a plenum located at the back of the oven. Blowers are typically provided to move heat in the plenum through passageways to metal fingers that open into the oven at appropriate spacings from the conveyor belt to deliver streams of hot air onto food products present on the conveyor, as discussed earlier. The heat source is cycled on and off as necessary by a controller responding to signals from temperature sensors (e.g., thermocouples) positioned, for example, at the inlet and outlet ends of the oven tunnel.

In some embodiments of the present invention, uniform heating from one end of the tunnel **24** to the other is achieved by apportioning the tunnel **24** into two or more segments and by providing independent temperature sensing and independent delivery of heated air to each segment. This is shown diagrammatically in FIG. **4**, where the oven **20** has a pair of burners **60** and **62** with respective heating flames **64** and **66** supplying heat to respective independent plenums **68** and **70** associated with segments **20**A and **20**B of the oven **20**. The heat in plenums **68** and **70** is blown into the two oven segments **20**A, **20**B by separate blower fans **72** and **74** through holes **75** and **77** in groupings of top fingers **76** and **78** (and through holes in corresponding groupings of bottom fingers, not shown) associated with the respective oven segments **20**A, **20**B.

A number of different types of fans **72**, **74** can be utilized for supplying heated air within the oven **20**, and can be driven by any type of motor. As will be described in greater detail below, it is desirable in some embodiments to control the speed of either or both fans **72**, **74** based at least in part upon one or more temperatures sensed within the oven **20**, one or more positions of food within, entering, or exiting the oven **20**, and/or the passage of one or more predetermined periods of time. To provide control over fan speed based upon any of these factors, the fans **72**, **74** can be driven by motors (not shown) coupled to and controlled by the controller **42**. In some embodiments, the fans **72**, **74** are driven by variable-speed motors coupled to and controlled by the controller **42**. Power can be supplied to each variable-speed motor by, for example, respective inverters. In some embodiments, each

inverter is a variable-speed inverter supplying power to the motor at a frequency that is adjustable to control the speed of the motor and, therefore, the speed of the fan **72**, **74**. An example of such an inverter is inverter Model No. MD60 manufactured by Reliance Electric (Rockwell Automation, Inc.). By utilizing variable speed motors supplied by power through respective inverters as just described, a significant degree of control over fan speed and operation is available directly via the controller **42** connected to other components of the control system.

The temperatures in each of the oven segments **20**A, **20**B can be monitored by temperature sensors (e.g., thermocouples or other temperature sensing elements) **80** and **82**, which are shown in FIG. **4** as being mounted near the inlet end **26** and the outlet end **28** of the oven **20**. Either or both temperature sensors **80**, **82** can be located in respective plenums **68**, **70** as shown in the figures. In some alternative embodiments, either or both temperature sensors **80**, **82** are instead located within the chamber through which the conveyor **22** moves. Either or both sensors **80**, **82** can be positioned nearer the midpoints of the segments **20**A, **20**B or in other locations, if desired. In addition to or in place of either or both temperature sensors **80**, **82**, one or more position sensors **79**, **81** and/or **83**, **85** can be located to detect the position of a pizza on the conveyor **22**, and to thereby control one or more operations of the oven **20** as a result of such position detection (described in greater detail below). Furthermore, in those embodiments in which the oven **20** is heated by one or more gas burners, one or more gas output sensors (not shown) can be positioned to detect the amount of fuel supplied to the oven **20**. This information can be provided to the controller **42** in order to control one or more operations of the oven **20**, such as to turn a conveyor **22** and/or fan **72**, **74** on or off, and/or to adjust the speed of the conveyor **22** and/or fan **72**, **74**.

The operation of the oven proceeds as shown in FIGS. **5**A-**5**C, which includes a diagrammatic representation of a pizza moving through the oven tunnel **24** below graphs showing the changing BTU output of the burners **60**, **62** and the corresponding blower output as the pizza advances through the tunnel **24**. Thus, a raw pizza **32**R is shown in FIG. **5**C resting on the conveyor **22** before the pizza enters the oven tunnel **24**. In the illustrated embodiment of FIG. **5**C, the oven **20** has been heated to a desired temperature.

The oven **20** according to some embodiments of the present invention can detect the presence of a raw pizza **32**R on the conveyor **22** by a position sensor **79**, **81**. The position sensor **79**, **81** can take a number of different forms, and need not necessarily comprise components on opposite sides of the conveyor **22** as illustrated in FIG. **4**. By way of example only, the position sensor **79**, **81** can be an optical sensor positioned to detect the interruption of a beam of light (e.g., by a raw pizza **32**R) extending across the conveyor **22** at the entrance of the left tunnel segment **20**A, an infrared detector positioned to detect a raw pizza **32**R having a reduced temperature on the conveyor **22**, a motion sensor positioned to detect motion of a raw pizza **32**R upon the conveyor **22**, or any other sensor capable of detecting the presence of the raw pizza **32**R on the conveyor **22**. In the illustrated embodiment of FIG. **4**, for example, the position sensor **79**, **81** comprises a light source **79** emitting a laser or other beam of light across the conveyor **22** to a reflector **81**, which reflects the beam of light back to a photocell **81** (which may or may not be associated with the light source **79**). Alternatively, the light source **79** and the photocell **81** can be on opposite sides of the conveyor **22**, in which case an interruption in the beam of light can still be detected by the photocell **81**.

In those embodiments of the present invention employing a position sensor **79**, **81** at or adjacent the entrance of the left tunnel segment **20**A as just described, the position sensor **79**, **81** can be coupled to the controller **42**, and can send one or more signals to the controller **42** responsive to the detection of a raw pizza **32**R (or lack thereof) on the conveyor **22**. The controller **42** can be responsive to the position sensor **79**, **81** by increasing the BTU output of either or both burners **60**, **62**. In some embodiments, the controller **42** responds to the signal(s) from the position sensor **79**, **81** by increasing the BTU output of the burner **60** of the left tunnel segment **20**A, and can also respond to the signal(s) from the position sensor **79**, **81** by increasing the speed of either or both fans **72**, **74**. Either response can occur immediately or after a lag time, and can occur relatively abruptly or gradually.

For example, the controller **42** can gradually increase the speed of both fans **72**, **74** from a slow, relatively quiet standby level **71** to a full speed level **73**, thereby supplying additional heat to both segments **20**A and **20**B of the tunnel (although an increase supply of heat can instead be provided to only one of the segments **20**A, **20**B in other embodiments). As another example, the controller **42** can respond to the signal(s) from the position sensor **79**, **81** by quickly increasing the BTU output of the burner **60** of the left tunnel segment **20**A, by gradually increasing the BTU output of the burner **60** as the raw pizza **32**R enters the left tunnel segment **20**A, or by quickly or gradually increasing the BTU output of the burner **60** only after a set period of time permitting either or both fans **72**, **74** to increase in speed. In these and other embodiments, the controller **42** can respond to the signal(s) from the position sensor **79**, **81** by gradually increasing the BTU output of the burner **62** of the right tunnel segment **20**, by gradually or quickly increasing the BTU output of the burner **62** following a lag time (e.g., a predetermined period of time that can be independent or dependent upon the speed of the conveyor **22**), or by changing the BTU output of the burner **62** in any other manner.

If desired, the temperature sensor **80** can be used to detect the presence of a raw pizza **32**R on the conveyor **22**. For example, as the raw pizza **32**R enters the oven **20** and approaches position **32**(**1**), it draws heat causing sensor **80** (FIG. **4**) to call for the controller **42** to supply additional gas to the burner **60** and/or to increase the speed of either or both fans **72**, **74**. The controller **42** can respond to detection of the raw pizza **32**R by the temperature sensor **80** in any of the manners described above with reference to the position sensor **79**, **81**. The position sensor **79**, **81** and the temperature sensor **80** can be connected to the controller **42** in parallel, thereby enabling the controller **42** to change the BTU output of the burner **60** and/or the speed of either or both fans **72**, **74** based upon signals received by the position sensor **79**, **81** or the temperature sensor **80**.

Until air in the plenum(s) **68**, **70** has been sufficiently heated, the above-described fan control generates a reduced amount of heat loss and fan noise from the oven tunnel **24** into the surrounding environment, and defines a load management setback of the oven **20**. The establishment of a quiet and reduced airflow standby state of the fan(s) **72**, **74** is an advantage of the load management setback. Also, while the fans **72**, **74** in the illustrated embodiment are operated in tandem, in alternate embodiments they could be operated independently of one another (e.g., so that the fan speeds are increased from their slower steady state level on an independent "as-needed" basis). Finally, it is noted that the fans **72**, **74** in the illustrated embodiment operate at about 2900 RPM at full speed and at a level of about 1400 RPM when in the standby mode. The full speed and standby speeds can vary depending at least in part

upon design constraints of the oven **20**, the food being cooked, etc. For example, the standby mode of either or both fans **72**, **74** can be faster or slower as desired, such as a 2100 RPM standby speed for both fans **72**, **74**.

With continued reference to the illustrated embodiment of the present invention shown in FIGS. **5**A-**5**C, as a pizza advances to the right to position **32**(**2**), the pizza is now warmed. Therefore, less heat is drawn by the pizza, and the temperature in the first tunnel segment **20**A rises. In some embodiments, this temperature rise is detected by the temperature sensor **80** of the first tunnel segment **20**A, which can signal the controller **42** to reduce the supply of gas to the left burner **60**, thereby producing a reduction in BTU output as shown in FIG. **5**B. In these and other embodiments, the controller **42** can be triggered to reduce the supply of gas to the left burner **60** by a position sensor positioned in or adjacent the first tunnel segment **20**A to detect when the pizza has advanced to a location in the first tunnel segment **20**A. The position sensor can have any of the forms described above with reference to the position sensor **79**, **81** at or adjacent the entrance to the left tunnel segment **20**A. The lowered BTU output level can continue for any part or all of the remaining time that the pizza is in the first tunnel segment **20**A (e.g., all of such time as shown in the illustrated embodiment of FIG. **5**B).

Next, the pizza reaches the position **32**(**3**) shown in FIG. **5**C, and then passes the midpoint of the tunnel **24** between the two segments **20**A, **20**B. Since the pizza has exited, and there is therefore no further significant perturbation to the heating environment in segment **20**A, the controller **42** can lower the gas supply (and therefore the BTU output) of the left burner **60** to a reduced steady state. This reduction can be triggered by a threshold temperature change detected by the temperature sensor **80** in the first tunnel segment **20**A and/or by the temperature sensor **82** in the second tunnel segment **20**B. Alternatively or in addition, this reduction can be triggered by one or more signals from a position sensor positioned to detect when the pizza has advanced to a location between the first and second tunnel segments **20**A, **20**B (or near such a location). The position sensor can have any of the forms described above with reference to the position sensor **79**, **81** at or adjacent the entrance to the left tunnel segment **20**A.

With continued reference to FIGS. **5**A-**5**C, the right burner **62** supplies heat to the second tunnel segment **20**B. The sensor **82** corresponding to the second tunnel segment **20**B can initially detect a spillover of heat from the first tunnel segment **20**A (i.e., as the pizza enters and is in the first part of the baking process in the first tunnel segment **20**A). Upon detection of sufficient spillover heat (e.g., when the sensor **82** detects that a threshold temperature has been reached), the sensor **82** can trigger the controller **42** to drop the initial BTU output of the right burner **62**. However, when the partially cooked pizza approaches the right tunnel segment **20**B, the pizza draws heat from the second tunnel segment environment. This heat draw can also be detected by the sensor **82** of the second tunnel segment **20**B, which can trigger the controller **42** to supply additional gas to the burner **62** of the second tunnel segment **20**B. As a result, the BTU output of the right burner **62** can increase as the pizza moves to and through positions **32**(**4**), **32**(**5**), and **32**(**6**). The reduction and increase of right burner BTU output just described can also or instead be triggered by one or more signals from one or more position sensors positioned in or adjacent the second tunnel segment **20**B to detect when the pizza has advanced to one or more locations within the oven **20**. The position sensor(s) can have any of the forms described above with reference to the position sensor **79**, **81** at or adjacent the entrance to the left tunnel segment **20**A.

In some embodiments, when the pizza leaves the position **32**(**6**) and begins exiting the tunnel **24**, the temperature sensor **82** of the second tunnel segment **20**B can detect a rise in the tunnel temperature, and can trigger the controller **42** to reduce the output of the right burner **62** as shown in the BTU output graph of FIG. **5**B. The resulting reduction in temperature in the second tunnel segment **20**B can also be detected by the temperature sensor **80** of the first tunnel segment **20**A due to heat spillover between the two tunnel segments **20**A, **20**B, and can trigger the controller **42** to increase the output of the left burner **60** to maintain the steady state temperature between the two oven segments **20**A, **20**B. Alternatively, the controller **42** can automatically increase the output of the left burner **60** when the output of the right burner **62** is reduced (or near in time to such reduction of the right burner **62**). In some embodiments, the controller **42** can also respond by returning the speed of the fans **72**, **74** to a standby state. This change in fan operation can take place relatively abruptly or gradually, and can take place immediately after a threshold temperature is detected by either or both sensors **80**, **82** or after a predetermined period of time.

The increase of the left burner BTU output and the decrease in the right burner BTU output just described can also or instead be triggered by one or more signals from a position sensor positioned to detect when the pizza is exiting or has exited the right tunnel segment **20**B. For example, the oven **20** illustrated in FIG. **4** has a position sensor **83**, **85** (comprising a light source **83** and a photocell **85**) that is substantially the same as the position sensor **79**, **81** at the entrance to the left tunnel segment **20**A described above. In other embodiments, the position sensor **83**, **85** can have any of the forms described above with reference to the position sensor **79**, **81** at or adjacent the entrance to the left tunnel segment **20**A.

The position sensor **83**, **85** and the temperature sensor **82** can be connected to the controller **42** in parallel, thereby enabling the controller **42** to change the BTU output of the burner **62** and/or the speed of either or both fans **72**, **74** based upon signals received by the position sensor **83**, **85** or the temperature sensor **82**.

The BTU output of either or both burners **60**, **62** can be controlled by the controller **42** in any manner desired. For example, the gas supply to either or both burners **60**, **62** can be lowered or raised by the controller **42** relatively abruptly or gradually upon detection of threshold temperatures by either or both temperature sensors **80**, **82**, after a set period of time, and/or after sufficient movement of the pizza is detected by a position sensor.

Accordingly, in some embodiments, the controller **42** can control either or both fans **72**, **74** based at least in part upon the temperature detected by a temperature sensor **80**, **82**, an amount of time elapsed following a change in power supply to a burner **60**, **62**, and/or the detection of a position of pizza or other food on the conveyor **22** by a photo sensor **79**, **81**, **83**, **85**. For example, in some embodiments the speed of either or both fans **72**, **74** is increased after air driven by the fan(s) **72**, **74** has been sufficiently heated.

Similarly, in some embodiments the controller **42** can control the BTU output of either or both burners **60**, **62** based at least in part upon the temperature detected by a temperature sensor **80**, **82**, an amount of time elapsed following a change in speed of a fan **72**, **74**, and/or the detection of a position of pizza or other food on the conveyor **22** by a photo sensor **79**, **81**, **83**, **85**. For example, in some embodiments the BTU

output of either or both burners **60**, **62** is increased only after either or both fans **72**, **74** are brought up to a threshold speed.

In some embodiments, the oven **20** can include one or more temperature sensors **93**, **95** (e.g., thermocouples) coupled to the controller **42** and positioned to detect the BTU output of either or both burners **60**, **62**. Using such an arrangement of elements, a speed change of the fans **72**, **74** can be delayed for a desired period of time in order to prevent undue cycling of the fans **72**, **74** as temperatures rise and fall within the tunnel **24** and as the BTU output of the burners **60**, **62** rise and fall. In this regard, as the BTU output detected by either or both temperature sensors **93**, **95** decreases below a threshold level, power to either or both fans **72**, **74** can remain unchanged for a set period of time, after which time power to the fans **72**, **74** can be reduced to a standby speed of the fans **72**, **74**.

In the illustrated embodiment, for example, a relay **91** coupled to the temperature sensors **93**, **95**, is also coupled to the controller **42**, and cooperates with the controller **42** to reduce power to either or both fans **72**, **74** in a manner as just described. In this embodiment, when the output of either burner **60**, **62** falls below a threshold value (e.g., 60% of maximum output in some embodiments), the relay **91** and controller **42** enter into a timed state. When the output of either burner **60**, **62** remains below the threshold value for a set period of time (e.g., five minutes in some embodiments), either or both burners **60**, **62** are shut off. Either or both burners **60**, **62** can be re-activated in some embodiments by detection of a sufficiently low threshold temperature by either of the tunnel segment temperature sensors **80**, **82**, by sufficient movement of a pizza detected by any of the position sensors described above, after a set period of time has passed, and the like. Thus, as the BTU output of either or both burners **60**, **62** move above and below one or more threshold levels, the tendency of the fans **72**, **74** to cycle (e.g., between high and low speed levels, and in some cases between on and off states) is reduced. Instead, the fans **72**, **74** can remain at a full speed level until a lowered BTU level is established for at least the set period of time, such as for five minutes in the illustrated embodiment.

Under some operating conditions, the BTU output of the burners **60**, **62** in some embodiments can be reduced to a relatively low level (e.g., as low as a 5:1 air to gas ratio, in some cases). A description of burner features enabling this low BTU burner output is provided below. Relatively low (and relatively high) burner BTU output can generate problems associated with poor combustion. For example, relatively low burner BTU output can generate incomplete combustion and flame lift-off. To address these issues, the controller **42** in some embodiments of the present invention is adapted to turn gas to either or both burners **60**, **62** completely off in the event that either or both temperature sensors **80**, **82** detect that a low threshold temperature has been reached.

In some of these embodiments, when either temperature sensor **80**, **82** detects that a sufficiently low temperature has been reached, the controller **42** responds by turning off gas to the burner **60**, **62** associated with that temperature sensor **80**, **82** (either immediately or if a higher temperature is not detected after a set period of time). The supply of gas to the burner **60**, **62** can be restored after a period of time and/or after the temperature sensor **80**, **82** detects a temperature below a lower predetermined threshold temperature. In this manner, the burner **60**, **62** can be cycled in order to avoid operating the burner **60**, **62** at a very low BTU output. As will be described in greater detail below, in some embodiments two or more burners **60**, **62** will always be on or off together. In such cases, the controller **42** can respond to a low threshold temperature by turning off the supply of gas to both burners **60**, **62**, and can restore the supply of gas to both burners **60**, **62** after a period of time and/or after the temperature sensor **80**, **82** detects that a lower threshold temperature has been reached.

Similarly, in some embodiments, when either temperature sensor **80**, **82** detects that a sufficiently high temperature has been reached, the controller **42** responds by turning off gas to the burner **60**, **62** associated with that temperature sensor **80**, **82** (either immediately or if a lower temperature is not detected after a set period of time). The supply of gas to the burner **60**, **62** can be restored after a period of time and/or after the temperature sensor **80**, **82** detects a temperature below the low threshold temperature or a sufficient drop in temperature. In this manner, the burner **60**, **62** can be cycled in order to avoid operating the burner **60**, **62** at a very high BTU output. As will be described in greater detail below, in some embodiments two or more burners **60**, **62** will always be on or off together. In such cases, the controller **42** can respond to a high threshold temperature by turning off the supply of gas to both burners **60**, **62**, and can restore the supply of gas to both burners **60**, **62** after a period of time and/or after the temperature sensor **80**, **82** detects a temperature below the low threshold temperature or an otherwise sufficient drop in temperature.

Although only two tunnel segments **20**A, **20**B are used in the illustrated embodiment, more than two tunnel segments can be used in other embodiments, each such alternative embodiment having one or more tunnel segments with any combination of the elements and features described above with reference to the illustrated embodiment. Also, as described above, the illustrated embodiment uses separate burners **60**, **62** for each tunnel segment **20**A, **20**B. In other embodiments, it is possible to achieve the desired segment-specific heating using a single burner and conventional structure and devices to direct heat to each segment independently in response to signals from temperature sensors associated with each of the segments. Finally, although gas burner(s) are preferred, other heating elements and devices can instead or also be used (e.g., one or more electric heating elements). As used herein and in the appended claims, the term "heating elements" refers to gas burners, electric heating elements, microwave generating devices, and all alternative heating elements and devices.

Energy Management

In some embodiments, it may be desirable to operate the oven **20** in one or more energy saving modes. Components of the oven **20** that can be controlled to provide energy savings may include either or both burners **60** and **62**, either or both fans **72** and **74**, and/or the conveyor **22**.

Saving energy with the burners **60** and **62** may be achieved by lowering the temperature threshold in one or both of the plenums **68** and **70** that the burners **60** and **62** heat. This lower threshold can cause one or both of the burners **60** and **62** to be on less often, or to operate at a lower output, resulting in energy savings. Additionally, one or both of the burners **60** and **62** may be turned off completely.

Saving energy with the fans **72** and **74** may be achieved by reducing the speed or RPMs of one or both of the fans **72** and **74** which can require less power and, therefore, save energy. Additionally, one or both of the fans **72** and **74** may be turned off completely.

Saving energy with the conveyor **22** may be achieved by slowing down or turning off the conveyor **22**.

While it may be possible to set the plenum temperature, fan speed, and conveyor speed to any number of values between

a minimum and a maximum, it may be more practical to choose one or more settings in the range between each minimum and maximum.

Energy management strategies may include controlling any one or more of the burners **60**, **62**, fans **72**, **74**, and conveyor **22** of the oven **20** individually or in combination and/or controlling such components in the different segments of the oven **20** individually or in combination.

Energy management events which cause one or more energy management strategies described herein to execute may be triggered by one or more actions, alone or in combination, including a predetermined amount of elapsed time, feedback from one or more temperature sensors, feedback from one or more position sensors, feedback from one or more motion detectors, and the like.

FIG. **12** illustrates a process for an energy management mode that can be utilized for a conveyor oven, such as the pizza oven **20** of FIG. **4**. At step **300**, the controller **42** can check for the presence of a pizza on conveyor **22**. A pizza can be detected in any of the manners described herein, such as by one or more optical sensors **79** and **81**. If a pizza is detected, a timer can be reset, either or both of the fans **72** and **74** can be set to a higher speed, and/or either or both of the burners **60**, **62** can be set to a higher level to raise the temperature in one or both of the plenums **68**, **70** to a higher level (steps **305**, **310**, and **315**). If no pizza is detected by the sensors **79** and **81** (step **300**), the controller **42** can check a timer to determine the period of time since the last pizza was put on the conveyor **22** (step **320**). If the timer is less than a predetermined threshold, the operation of the oven **20** can remain unchanged and the controller **42** can continue to check for the presence of a pizza (step **300**). If the timer exceeds the predetermined threshold, the controller **42** can go into an energy saving mode. In this energy saving mode, either or both fans **72** and **74** can be set to a low speed and the temperature can be set to a low value (steps **325** and **330**). The controller **42** can then continue to check for the presence of a pizza on the conveyor **22** (step **300**). The controller **42** can remain in this energy saving mode until a pizza is detected on the conveyor **22** at step **300**.

FIG. **13** illustrates another embodiment of a process for an energy management mode that can be utilized for a conveyor oven, such as the pizza oven **20** of FIG. **4**. At step **335**, the controller **42** can check for the presence of a pizza on conveyor **22**. A pizza can be detected in any of the manners described herein, such as by one or more optical sensors **79** and **81**. If a pizza is detected, a timer can be reset, either or both of the fans **72** and **74** can be set to a higher speed, and/or either or both of the burners **60**, **62** can be set to a higher level to raise the temperature in one or both of the plenums **68**, **70** to a higher level (steps **340**, **345**, and **350**). Since, as will be explained later, the oven temperature can be relatively low (e.g., if the oven has been in an energy management mode), it may be necessary to wait until the temperatures in the plenums **68** and **70** reach levels that will result in temperatures satisfactory for baking when the pizza arrives in the respective plenums before allowing the pizza on conveyor **22** to enter the oven **20**. Therefore, at step **355**, the controller **42** can wait until the temperatures of the oven **20** reach their thresholds.

Once the temperatures of the oven **20** reach their thresholds, the conveyor **22** can start (step **360**) and the pizza can enter the oven **20** and bake. If no pizza is detected by the sensors **79** and **81** (step **335**), the controller **42** can check a timer to determine the period of time since the last pizza was put on the conveyor **22** (step **365**). If the timer is less than a predetermined threshold, the operation of the oven **20** can remain unchanged and the controller **42** can continue to check for the presence of a pizza (step **335**). If the timer exceeds the predetermined threshold, the controller **42** can enter an energy saving mode. In this energy saving mode, either or both fans **72** and **74** can be set to a low speed (step **370**), the burner **62** for either or both plenums **68**, **70** can be turned off (e.g., the back plenum **70** can be turned off as indicated at step **375**), and the temperature in the first plenum **68** can be set to a lower level (step **380**). The conveyor **22** can also be turned off (step **385**). The controller **42** can then continue to check for the presence of a pizza on the conveyor **22** (step **335**). The controller **42** can remain in this energy saving mode until a pizza is detected on the conveyor **22** at step **335**.

FIG. **14** illustrates another embodiment of a process for an energy management mode that can be utilized for a conveyor oven, such as the pizza oven **20** of FIG. **4**. At step **400**, the controller **42** can check for the presence of a pizza on conveyor **22**. A pizza can be detected in any of the manners described herein, such as by one or more optical sensors **79** and **81**. If a pizza is detected, a timer can be reset, either or both of the fans **72** and **74** can be set to a higher speed, and/or either or both of the burners **60**, **62** can be set to a higher level to raise the temperature in one or both of the plenums **68**, **70** to a higher level (steps **405**, **410**, and **415**). Since, as will be explained later, the oven temperature can be relatively low (e.g., if the oven has been in an energy management mode), it may be necessary to wait until the temperatures in the plenums **68** and **70** reach levels that will result in temperatures satisfactory for baking when the pizza arrives in the respective plenums before allowing the pizza on conveyor **22** to enter the oven **20**. Therefore, at step **420**, the controller **42** can wait until the temperatures of the oven **20** reach their thresholds.

Once the temperatures of the oven **20** reach their thresholds, the conveyor **22** can start (step **425**) and the pizza can enter the oven **20** and bake. If no pizza is detected by the sensors **79** and **81** (step **400**), the controller **42** can check a timer to determine the period of time since the last pizza was put on the conveyor **22** (step **420**). If the timer is less than a predetermined threshold, the operation of the oven **20** can remain unchanged and the controller **42** can continue to check for the presence of a pizza (step **400**). If the timer exceeds the predetermined threshold, the controller **42** can go into an energy saving mode. In this energy saving mode, either or both fans **72** and **74** can be turned off (step **435**), either or both burners **60** and **62** can be turned off (step **440**), and the conveyor **22** can be turned off (step **445**). The controller **42** can then continue to check for the presence of a pizza on the conveyor **22** (step **400**). The controller **42** can remain in this energy saving mode until a pizza is detected on the conveyor **22** at step **400**.

FIG. **15** illustrates another embodiment of a process for an energy management mode that can be utilized for a conveyor oven, such as the pizza oven **20** of FIG. **4**. The process illustrated in FIG. **15** combines much of the processes illustrated in FIGS. **12** and **13**. At step **450**, the controller **42** can check for the presence of a pizza on conveyor **22**. A pizza can be detected in any of the manners described herein, such as by one or more optical sensors **79** and **81**. If a pizza is detected, a timer can be reset, either or both fans **72** and **74** can be set to a high speed, and the temperature can be set to a high level (steps **455**, **460**, and **465**). If no pizza is detected by the sensors **79** and **81** (step **450**), the controller **42** can check a timer to determine the period of time since the last pizza was put on the conveyor **22** (step **470**). If the timer is less than a first predetermined threshold, the operation of the oven **20** can remain unchanged and the controller **42** can continue to check for the presence of a pizza (step **450**). If the timer

exceeds the first predetermined threshold, the controller **42** can check the timer to determine if it exceeds a second predetermined threshold (step **475**). The second predetermined threshold is a period of time that is longer than the first predetermined threshold. If the timer does not exceed the second predetermined threshold, the controller **42** can enter a first energy saving mode.

In this first energy saving mode, either or both fans **72** and **74** can be set to a low speed and the temperature can be set to a low value (steps **480** and **485**). The controller **42** can then continue to check for the presence of a pizza on the conveyor **22** (step **450**). The controller **42** can remain in this first energy saving mode until a pizza is detected on the conveyor **22** at step **450** or until the threshold period of time since the last pizza was detected on the conveyor **22** (e.g., until the second predetermined threshold of the timer is exceeded). If, at step **475**, the timer exceeds the second predetermined threshold, the controller **42** can enter a second energy saving mode.

In the second energy saving mode, either or both burners **60**, **62** can be turned off (e.g., the burner **62** for the back plenum **70** can be turned off as indicated at step **490**), and the conveyor **22** can be turned off (step **495**). The controller **42** can then continue to check for the presence of a pizza on the conveyor **22** (step **500**). The controller **42** can remain in this second energy saving mode until a pizza is detected on the conveyor **22** at step **500**. If a pizza is detected at step **500**, the timer can be reset, either or both fans **72** and **74** can be set to a high speed, and the temperature can be set to a high level (steps **505**, **510**, and **515**). Since, as will be explained later, the oven temperature can be relatively low (e.g., if the oven has been in an energy management mode), it may be necessary to wait until the temperatures in the plenums **68** and **70** reach levels that will result in temperatures satisfactory for baking when the pizza arrives in the respective plenums before allowing the pizza on conveyor **22** to enter the oven **20**. Therefore, at step **520**, the controller **42** can wait until the temperature(s) of the oven **20** reach their threshold(s). Once the temperatures of the oven **20** reach their thresholds, the conveyor **22** can start (step **525**) and the pizza can enter the oven **20** and bake. The controller **42** can then exit the energy saving modes and continue checking for pizzas at step **450**.

FIG. **16** illustrates another embodiment of a process for an energy management mode that can be utilized for a conveyor oven, such as the pizza oven **20** of FIG. **4**. The process illustrated in FIG. **16** combines much of the processes illustrated in FIGS. **12**, **13**, and **14**. At step **550**, the controller **42** can check for the presence of a pizza on conveyor **22**. A pizza can be detected in any of the manners described herein, such as by one or more optical sensors **79** and **81**. If a pizza is detected, a timer can be reset, either or both fans **72** and **74** can be set to a high speed, and the temperature can be set to a high level (steps **555**, **560**, and **565**). If no pizza is detected by the sensors **79** and **81** (step **550**), the controller **42** can check a timer to determine the period of time since the last pizza was put on the conveyor **22** (step **570**). If the timer is less than a first predetermined threshold, the operation of the oven **20** can remain unchanged and the controller **42** can continue to check for the presence of a pizza (step **550**). If the timer exceeds the first predetermined threshold, the controller **42** can check the timer to determine if it exceeds a second predetermined threshold (step **575**). The second predetermined threshold is a period of time that is longer than the first predetermined threshold. If the timer does not exceed the second predetermined threshold, the controller **42** can enter a first energy saving mode.

In the first energy saving mode, either or both fans **72** and **74** can be set to a low speed, and the temperature can be set to a low value (steps **580** and **585**). The controller **42** can then continue to check for the presence of a pizza on the conveyor **22** (step **550**). The controller **42** can remain in this first energy saving mode until a pizza is detected on the conveyor **22** at step **550** or until the threshold period of time since the last pizza has been detected on the conveyor **22** (e.g., until the second predetermined threshold of the timer is exceeded). If, at step **575**, the timer exceeds the second predetermined threshold, the controller **42** can enter a second energy saving mode.

In the second energy saving mode, either or both burners **60**, **62** can be turned off (e.g., the burner **62** for the back plenum **70**, can be turned off as indicated at step **590**), and the conveyor **22** can be turned off (step **595**). The controller **42** can then continue to check for the presence of a pizza on the conveyor **22** (step **600**). If a pizza is detected at step **600**, the timer can be reset to zero, either or both fans **72** and **74** can be set to a high speed, and the temperature can be set to a high level (steps **605**, **610**, and **615**). Since, as will be explained later, the oven temperature can be relatively low (e.g., if the oven has been in an energy management mode), it may be necessary to wait until the temperatures in the plenums **68** and **70** reach levels that will result in temperatures satisfactory for baking when the pizza arrives in the respective plenums before allowing the pizza on conveyor **22** to enter the oven **20**. Therefore, at step **620**, the controller **42** can wait until the temperature(s) of the oven **20** reach their threshold(s). Once the temperatures of the oven **20** reach their thresholds, the conveyor **22** can start (step **625**) and the pizza can enter the oven **20** and bake. The controller **42** can then exit the energy saving modes and continue checking for pizzas at step **550**.

If no pizza is detected by the sensors **79** and **81** (step **600**), the controller **42** can check a timer to determine the period of time since the last pizza was placed on the conveyor **22** (step **630**). If the timer is less than a third predetermined threshold, the operation of the oven **20** can remain in the second energy saving mode, and the controller **42** can continue to check for the presence of a pizza (step **600**). The third predetermined threshold is a period of time that is longer than the second predetermined threshold. If the timer exceeds the third predetermined threshold, the controller **42** can enter a third energy saving mode. In this third energy saving mode either or both fans **72** and **74** can be turned off (step **635**) and the first burner **60** can be turned off (step **640**). The controller **42** can then continue to check for the presence of a pizza on the conveyor **22** (step **600**). The oven **20** may remain in the third energy savings mode until a pizza is detected at step **600**. Once a pizza is detected at step **600**, processing continues at step **605** as previously described.

Embodiments of three energy savings modes have been illustrated along with two combinations of the illustrated energy savings modes. Further embodiments can include, for example, combining the embodiments of FIGS. **12** and **14** or FIGS. **13** and **14**. Further, other methods of controlling the components of the conveyor oven can be utilized to create additional energy saving modes and combinations thereof.

As one skilled in the art will understand, numerous strategies and combinations of strategies exist for implementing energy management for an oven **20**. Considerations in deciding which strategies to implement include the time it will take to be ready for baking after entering an energy saving mode and the amount of energy required to reach baking temperature following an energy saving mode. As such it can be desirable to provide multiple energy management strategies and allow users to choose the strategy or combination of strategies that best meets their needs.

In some embodiments, one or more remote input devices can provide an indication to the controller **42** that food product (e.g., a pizza) needs to be baked. Such remote input devices can change the operational state of the oven **20**, such as by providing trigger mechanisms (other than those described elsewhere herein) to prepare the oven for cooking. Remote input devices can include one or more push buttons, switches, knobs, keypads, operator interfaces, cash registers, or other user manipulatable devices, one or more sensors (e.g., pressure sensors, limit switches, optical sensors), a computer, and the like. The remote input device can communicate with the controller **42** in any suitable manner, including a hard-wired connection, a wireless connection, an internet connection, and any combination of such connections.

FIG. **24** illustrates an exemplary layout of a kitchen **1000** for cooking and serving pizzas. A counter **1005** can include one or more cash registers **1010** for taking customer orders. In addition to the conveyor oven **20**, the kitchen **1000** can include a refrigerator **1015**, a preparation table **1020**, a final preparation table **1030**, and/or any number of other food preparation and cooking stations and equipment. Other examples of such cooking stations and equipment include walk-in coolers, sinks, racks, food processing equipment (e.g., mixers, grills, and the like), and the like. One or more remote devices can be associated with any of such cooking stations or equipment, and can provide indication(s) that food product needs to be prepared by the conveyor oven **20**.

For example, in some embodiments, a switch or sensor of the refrigerator **1015** can detect when the door of the refrigerator **1015** has been opened, and can communicate with the controller **42** via link **1040**. As another example, in some embodiments, a switch or sensor of the preparation table **1020** can detect that food product is being made (e.g., by detecting the weight of food product placed upon the preparation table, optically detecting the presence of such food product, and the like), and can communicate with the controller via link **1045**. As another example, in some embodiments, one or more cash registers **1010** can inform the controller **42** via links **1050** and **1055** when a customer has ordered a pizza. As yet another example, the conveyor oven **20** can be provided with one or more proximity sensors adapted to detect the presence of a cooking element (e.g., a cooking pan, tray, container, and the like) within a range of distance from such sensors, and can communicate with the controller via a link. In such cases, the sensor can be an RFID sensor, an LED sensor, and the like, wherein the cooking element is adapted to be recognized by the sensor, such as by being provided with an antenna on or embedded within the cooking element. Other types of remote devices can be used in place of or in addition to those just described to inform the controller **42** that food product (e.g., one or more pizzas) needs to be cooked, thereby enabling the controller **42** to change the operational state of the oven **20** accordingly.

In some embodiments, the controller **42** receives an indication from a remote device that a food product needs to be cooked (e.g., that a pizza ordered by a customer at a cash register will need to be cooked). The controller **42** can immediately exit any energy savings mode it is in and enter an operating mode (e.g., a baking mode) where the conveyor **22** is turned on. In some embodiments, the speed of one or more fans **72**, **74** can be increased and/or the heat output of one or more heating elements **60**, **62** can be increased in the operating mode of the oven **20**. Also, in other embodiments, the controller **42** may keep the oven **20** in an energy saving mode for a period of time before entering the operating mode. The period of time the controller **42** keeps the oven **20** in the energy saving mode can be determined based at least in part upon the temperature of the oven **20** and/or a length of time until baking is to begin.

For example, after receiving an indication from a remote device that food product needs to be cooked by the oven **20**, the controller **42** can detect a temperature of the oven **20** and can compare the temperature of the oven **20** to a desired cooking temperature. The controller **42** can then calculate the length of time (or use a look-up table to determine the length of time) the oven **20** needs to heat up from the present temperature in the oven **20** to the desired cooking temperature. The controller **42** can also know the amount of time from when the controller **42** receives the indication from the remote device until the food product is actually ready to be cooked (e.g., the preparation time). If the time needed to heat the oven **20** to the cooking temperature is less than the preparation time, the oven **20** would reach the desired cooking temperature before the food product is ready to be cooked if the oven began heating up immediately upon receiving the indication from the remote device. Therefore, the controller **42** can delay heating the oven **20**, such as until the remaining preparation time equals the amount of time needed to heat the oven **20** to the desired cooking temperature.

In some embodiments, after receiving an indication from a remote device that food product needs to be cooked by the oven **20**, the controller **42** can delay heating the oven **20** based at least in part upon a known time by which the food product must be delivered or a desired cooking completion time. The time to delivery can be based on a time of day (e.g., shorter during lunch and longer during dinner) or a variable time (e.g., the length of time until a delivery person will be available to deliver the food product). The cooking completion time can be based upon an anticipated dining rush or other event. The controller **42** can know the length of time the oven **20** needs to reach the baking temperature based at least in part upon the present temperature of the oven **20** as discussed above. The controller **42** can also know the total cooking time of the food product and the length of time needed after the food product is cooked and before the food product is ready for serving or delivery (final preparation time). For example, the controller **42** receives an indication from a remote device that a pizza needs to be cooked. The controller **42** knows that the total baking time combined with the final preparation time is a certain length of time. If a delivery person will not be available to deliver the pizza until some time later, the controller **42** can determine when to heat the oven **20** based on when the delivery person will arrive minus the baking and final preparation time, and minus the time to heat the oven **20** to the baking temperature. In this manner, the pizza can be hot and fresh when the delivery person is ready to begin his or her delivery run.

After a cooking process is complete, the controller **42** can automatically cause the oven **20** to enter or return to an energy saving mode. This process can be delayed for a predetermined period of time in order to prevent unnecessary cycling of the oven **20**, can be overridden based upon an indication of additional food product to be cooked (e.g., an indication from a remote device as described above), or can be overridden based upon a reduction in oven demand (e.g., when the rate of food product to be cooked falls to a predetermined threshold).

FIGS. **25**A and B illustrate exemplary time lines for the operations described above. The controller **42** (see FIG. **24**) receives an indication from a remote device that a pizza needs to be cooked at **1100**. The controller **42** can then determine when the pizza will be ready to be placed on the conveyor **22** to be cooked (**1105**). The controller **42** knows the preparation time of the pizza (the difference between **1105** and **1100** in

FIG. **25**A), and can determine when to exit an energy-savings mode and to enter a heating mode (**1110**) by subtracting the heating time from the preparation time to arrive at the baking mode time (**1110**). The pizza then finishes baking at **1115** and is ready for delivery, following final preparation at **1120**.

FIG. **25**B illustrates an exemplary time line for the operation of an oven **20** when the time to delivery **1120** is greater than the total time needed to prepare and cook a pizza. The controller receives (at **1100**) an indication from a remote device that a pizza needs to be cooked. The controller **42** can know the delivery time **1120**. The controller **42** can work backward from the delivery time (**1120**) to determine the time to start heating the oven (**1110**) by subtracting the final preparation time (the difference between **1120** and **1115**), the baking time (the difference between **1115** and **1105**), and the heating time (the difference between **1105** and **1110**), wherein the heating time can be calculated based upon the difference between the temperature of the oven and the desired baking temperature.

In some embodiments, the controller **42** can enter an energy saving mode immediately at **1115**, provided a remote device has not indicated that another pizza needs to be cooked. The controller **42** can also attempt to maximize the energy savings by setting a target temperature of the oven **20**, during an energy saving mode, such that the heating time is equal to the difference between the time an indication that a pizza needs to be cooked is received from a remote device (**1100**) and the time baking is to begin (**1105**). This target temperature can add time (indicated by **1125**) to the heating time.

As described above, the controller **42** can receive one or more indications from a remote device to change oven operation based upon an anticipated demand for cooked food product. For example, in some embodiments, the indication(s) can turn the oven **20** on, can increase the heat output of one or more heating elements **60**, **62**, and/or can increase the speed of one or more fans **70**, **72**. Also or in addition, different portions of the oven **20** can be activated or de-activated in order to increase or decrease the cooking capacity of the oven **20** based upon the anticipated demand for cooked food product. Information reflecting the anticipated demand for cooked food product can also be received from the remote device(s), and can include data representing a quantity of food product to be cooked and/or a rate of food orders received).

For example, an oven **20** can have two or more conveyors **22** for moving food product through the oven **20**. The conveyors **22** can be stacked, can be side-by-side, or can have any other configuration described herein. For example, in a "split conveyor" (in which two adjacent conveyors **22** of the same or different width run in parallel), a first conveyor **22** can be operated independently of a second conveyor **22**, such as by moving faster or slower than the second conveyor, in a direction opposite the second conveyor, and the like. Feedback regarding either or both conveyors **22** (e.g., speed, temperature, and the like) can be provided to a controller **42** for display upon an operator interface and/or for adjustment of oven operation in any of the manners described herein. For example, the remote device can indicate to the controller **42** a quantity of pizzas that need to be cooked. The controller **42** can then determine if the first conveyor can cook the quantity of pizzas within a desired time. If the first conveyor cannot meet the demand, the controller **42** can cause the oven **20** to exit an energy saving mode (e.g., a mode in which the heating elements and/or fans associated with less than all conveyors are in an operating mode). As a result, one or more additional conveyors with associated heating elements and fans can be brought up to operating temperature only as the demand for pizzas requires. If the quantity of pizzas needing to be cooked approaches or exceeds the maximum capacity of the conveyor(s) currently in an operating mode, the controller **42** can put one or more other conveyors into an operating mode or a stand-by mode in which such other conveyor(s) are heated to a level above the energy savings mode but less than the baking temperature.

It should be noted that the various energy-saving modes described herein do not indicate or imply that the oven **20** is incapable of cooking food product while in an energy saving mode. In some embodiments, an oven **20** can still cook food product while in one or more energy savings modes. For example, one or more conveyors of a multiple-conveyor oven can enter an energy saving mode while still being able to cook food product on one or more other conveyors of the oven. As another example, a conveyor oven **20** in a period of low demand can operate with significantly less heat and/or fan output while still cooking food product, such as by slowing the conveyor **22** without significantly lengthening cooking time.

In some embodiments, the controller **42** can determine the amount of time necessary to heat the oven **20** to the desired cooking temperature and can use the cooking time, final preparation time, and the initial preparation time to calculate a time when a pizza will be ready. The controller **42** can then provide this time to a display to inform an operator of the length of time necessary to prepare and cook the pizza.

Contiguous Burners

Many different heat sources can be used to independently supply heating to each of the oven segments **20**A, **20**B, including a number of different gas burner configurations. By way of example only, FIG. **6** illustrates a single burner of a contiguous multiple burner configuration which has been found to be particularly useful. This burner **100** comprises a housing (e.g., an outer tube **102** as shown in the illustrated embodiment) attached to a mounting plate **104** which closes off the proximal end of the outer tube **102**. The outer tube **102** can have any shape desired, and in some embodiments has a relatively elongated shape as shown in the illustrated embodiment.

A smaller diameter venturi tube **106** is located within the outer tube **102** and has open distal and proximal ends **107**, **112**. The venturi tube **106** can be generally centered with its longitudinal axis along the longitudinal axis of the outer tube **102**, although non-concentric relationships between the venturi tube **106** and the outer tube **102** can instead be employed. In some embodiments, the venturi tube **106** is secured in place near its distal end **107** by a venturi support **108** encircling the venturi tube **106** and secured within the inside diameter **109** of the outer tube **102**. In some embodiments, a section **111** of the distal end **107** of the venturi tube **106** extends beyond the venturi support **108**.

A gas orifice **110** can be located in the mounting plate **104**, and can be spaced from the proximal open end **112** of the venturi tube **106**. In some embodiments (see FIG. **6**), the gas orifice **110** can be centered or substantially centered with respect to the open proximal end **112** of the venturi tube **106**, although other non-centered relationships between the venturi tube **106** and the gas orifice **110** are possible. The open proximal end **112** of the venturi tube **106** receives pressurized gas from the gas orifice **110**, and serves as a primary air inlet to admit a flow of air **115** into the venturi tube **106**. In other embodiments, air can enter the proximal end **112** of the venturi tube **106** through apertures or gaps in the end of the venturi tube **106**, through one or more conduits coupled to the

venturi tube **106**, or in any other manner. In some embodiments, powered air is supplied to that portion of the outer tube **102** below the venturi support **108**. For example, a powered air supply can be coupled to the outer tube **102** in the illustrated embodiment via a conduit **113** leading to the outer tube **102**.

The venturi support **108** can have any shape adapted to support the venturi tube **106** and/or to at least partially separate an interior portion of the outer tube **102** from a burn region **116** opposite the proximal end **112** of the venturi tube **106**. In some embodiments, the venturi support **108** is substantially disc shaped (e.g., see FIG. **6**A). The venturi support **108** can have an opening **117** (e.g., a central circular opening **117** as shown in FIG. **6**A) which fits about the circumference of the venturi tube **106**. Also, one or more apertures can be defined within the venturi support **108**, and in some cases can be defined between the venturi support **108** and the outer tube **102** and/or the venturi tube **106**. For example, in the illustrated embodiment, the venturi support **108** has edges **119** and **121** that partially define open gaps **123** and **125** between the circumference of the venturi support **108** and the inside diameter **109** of the outer tube **102**. These gaps **123**, **125** can admit secondary air to the burn region **116** opposite the proximal end **112** of the venturi tube **106** in order to help support combustion as will be explained in greater detail below. In an alternate embodiment, one or more adjustable shutters (e.g., a rotatable overlapping flap, wall, or disk) can be provided to adjust the amount of secondary air admitted to the burn region **116**.

In some embodiments, the venturi tube **106** can have a flame retention member **118** which can help prevent lift-off of the flame from the distal end **107** of the venturi tube **106**. As seen in FIG. **6**B, in some embodiments the flame retention member **118** comprises a ring **120** spaced from the inside diameter of the distal end **107** of the venturi tube **106**, thereby defining an annular space **122** between the ring **120** and the inside diameter of the venturi tube **106**. The ring **120** can be permanently or releasably retained in place with respect to the venturi tube **106** in a number of different manners, such as by one or more fingers, pins, clips, or other fasteners, by an apertured disc, and the like. In the illustrated embodiment, the ring **120** is retained in place by a corrugated member **128** located within the annular space **122**. The corrugated member **128** abuts the inside diameter of venturi tube **106** and the outside diameter of the ring **120**, and can be permanently attached to the venturi tube **106** and/or the ring **120**. Also, the corrugated member **128** can hold the ring **120** in place with respect to the venturi tube **106** by friction (e.g., between the corrugated member **128** and the venturi tube **106** and/or between the corrugated member **128** and the ring **120**.

In some embodiments, a target **124** is positioned opposite (and can be spaced from) the distal end **107** of the venturi tube **106**. This target **124** can be retained in this position with respect to the venturi tube **106** in any manner, including those described above with reference to the retention of the ring **120** within the venturi tube **106**. In the illustrated embodiment, for example, the target **124** is held in place by arms **126** extending from the target **124** to the outer tube **102**, although the arms **126** could instead extend to the venturi tube **106** or other adjacent structure of the burner **100**. The arms **126** can be permanently or releasably attached to the outer tube **102** and/or to the target **124** in any suitable manner, such as by welding, brazing, or riveting, by one or more snap-fits or other inter-engaging element connections, by clips, clamps, screws, or other fasteners, and the like. In the illustrated embodiment, the arms **126** are attached to the outer tube **102** by frictionally engaging the inside diameter **109** of the outer tube **102**.

The target **124** can have a convex shape, with an apex extending generally toward the distal end **107** of the venturi tube **106**. This target **124** can act to spread a portion **135** of the flame **134** emitted from the distal end **107** of the venturi tube **106**, facilitating mixing of gas escaping from the venturi tube **106** with primary air and secondary air being supplied to this region through the venturi tube **106** and the gaps **123**, **125**, respectively. In other embodiments, the target **124** can be substantially flat, can present a concave surface to the distal end **107** of the venturi tube **106**, can have any other shape suitable for spreading the flame **134** as described above, and can have an apex directed toward or away from the distal end **107** of the venturi tube **106**.

With continued reference to FIG. **6**, in some embodiments the outer tube **102** of the burner **100** is coupled to a flame tube **130**, such as by being received within an end of the flame tube **130**. The flame tube **130** can include a number of air openings **132** in any arrangement or pattern, thereby supplying further oxygen to the burning gas supporting the flame **134**, which can extend into the flame tube **130** when the burner **100** is turned on.

In some embodiments of the present invention, the oven **20** has at least one pair of contiguous burners **100** and **150** of the design illustrated in FIGS. **6**-**6**B. A pair of such burners **100**, **150** is illustrated in FIGS. **7**A and **7**B. The outer tubes **102**, **102'** of the respective burners **100**, **150** can be mounted to a common base plate **104**, and can each be fitted with a target **124**, **124'** as described above. Powered air for combustion can be supplied to a venturi enclosure **152** (e.g., a venturi box having a rectangular shape or any other shape desired) by way of an inlet **154** connected to a source of powered air, as described in more detail below.

In FIG. **7**B, the cover of the venturi enclosure **152** has been removed to expose a base **156** of the venturi enclosure **152**. The venturi enclosure **152** can have a respective base for each burner **100**, **150**, or can have a common base **156** (such as that shown in FIG. **7**B). The base **156** illustrated in FIG. **7**B has a pair of openings **158** and **160** associated respectively with each of the two burners **100**, **150**. Air supply tubes **162** and **164** can extend from openings **158** and **160** to the outer surface of each respective outer tube **102** and **102'**, with the distal edge of each air supply tube **162**, **164** shaped to follow and to sealingly engage the contour of the outer tubes **102**, **102'**. Outer tubes **102** and **102'** can each have a respective inlet **166** and **168** in communication with the air supply tubes **162**, **164**. Thus, powered air from a blower **155** (see FIG. **2**) entering the venturi enclosure **152** through the inlet **154** can pass through air supply tubes **162** and **164** and through air inlets **166** and **168** in the outer tubes **102**, **102'** of the burners **100**, **150**. In the illustrated embodiment, this powered air enters the venturi tubes **106** of the burners **100**, **150** through the proximal ends **107** of the venturi tubes **106**, and also passes through gaps **123** and **125** in the venturi support disks **108**.

Gas can be supplied to the burners **100**, **150** at their proximal ends **112** in any suitable manner, such as through a shared supply tube or through respective supply tubes **170** and **172** as shown in FIGS. **7**A and **7**B. The supply tubes **170**, **172** shown in FIGS. **7**A and **7**B have been cut away to facilitate viewing the rest of the burners **100**, **150**. The supply tube(s) can be mounted to the burners **100**, **150** in any manner, such as by one or more clamps, braces, or other fixtures, and can be mounted to one or more mounting frames, plates, or other structures adapted for this purpose. By way of example only, the supply tubes **170**, **172** in the illustrated embodiment are

mounted on brackets **174** and **176** attached to a common plate **178**, which in turn is attached to the base plate **104** of the burners **100**, **150**. Either or both gas supply tubes **170**, **172** can have any type of common valve or respective valves in order to control the supply of gas to the burners **100**, **150**. In the illustrated embodiment, for example, a threaded valve pin **180**, **182** on each supply tube **170**, **172** can be advanced and retracted for fine adjustment of gas supplied to the burners **100**, **150** through orifices (not shown) in the gas supply tubes **170**, **172** adjacent the gas orifices **110** (see FIG. **6**). The present design makes it possible to use a single main gas valve with any number of contiguous burners, and in some embodiments to also adjust each burner **100**, **150** independently of the others.

The distal ends of the outer tubes **102** and **102'** in the illustrated embodiment are shown in FIG. **8** (in which the target **124'** has been removed from the second burner **102'**). In this figure, the outer tubes **102**, **102'** are spot welded in place in a support plate **184**. In other embodiments, the support plate **184** is not required, in which case a common mounting plate **104** (or respective mounting plates **104** coupled together in any manner) can secure the outer tubes **102**, **102'** with respect to one another. In those embodiments in which a support plate **184** is utilized, the support plate **184** can be attached to the outer tubes **102**, **102'** in any manner, such as in any of the manners of attachment described above with reference to the attachment of the arms **126** to the outer tube **102**. Also, in some embodiments, the outer tubes **102**, **102'** and the burners **100**, **150** can be secured in place with respect to one another by a common support plate **184** (or by respective support plates coupled together in any manner) without this function being performed by one or more mounting plates **104** as described above.

With reference again to FIG. **8**, one burner **150** is provided with an igniter **186**, which produces a spark to ignite gas escaping from the distal end **107** of venturi tube **106** (see FIG. **6**). The flame produced crosses over to the other burner **150** by way of a cross-over structure which will discussed below. The burner **150** can be provided with a flame sensor **188** as a fail-safe measure to shut off the gas supply to both burners **100**, **150** should the flame produced in burner **150** fail to cross over to the adjacent contiguous burner **100**. In some embodiments, each burner **100**, **150** can be provided with a respective flame sensor **188** that can trigger gas shut-off when no flame is detected from the corresponding burner **100**, **150** after a sufficient period of gas supply time has elapsed. Also, in some embodiments (e.g., where independent burners **100**, **150** are used to deliver heat to each of the oven segments), each burner **100**, **150** can have its own independent igniter **186**.

In some embodiments of the present invention, the outer tubes **102** and **102'** of the burners **100**, **150** are each provided with at least one aperture **200**, **202** (see FIGS. **9**A and **9**C) through which fluid communication is established between the burn regions **116** of the burners **100**, **150**. By such fluid communication, heat from a flame **134** ignited in one of the burners **100**, **150** can raise the temperature in the other burner **150**, **100** sufficiently to ignite the other burner **150**, **100**.

The aperture(s) **200**, **202** in each of the outer tubes **102**, **102'** can be rectangular, round, oval, irregular, or can have any other shape desired. Also, the apertures **200**, **202** can be open to or located a distance from the ends of the outer tubes **102**, **102'** adjacent the burn regions **116** (e.g., see FIGS. **6** and **9**A), and can extend in a direction away from the respective venturi tubes **106** to locations past the targets **124**, **124'**. In the illustrated embodiment, for example, each of the outer tubes **102**, **102'** has a substantially rectangular aperture **200**, **202** located a distance from the end of the respective outer tube **102**, **102'** adjacent the region **116**.

The apertures **200**, **202** in the outer tubes **102**, **102'** can, in some embodiments, be joined by a conduit **212** extending between the apertures **200**, **202**. Such a conduit **210** can help direct heat to an unlit burner **100**, **150** to a lit burner **150**, **100** in order to light the unlit burner **100**, **150**. The conduit **210** can have any shape desired, such as a substantially rectangular or round cross-sectional shape, an irregular shape, and the like. The conduit **210** can be enclosed or partially enclosed, and in the illustrated embodiment of FIGS. **9**A-**9**D is enclosed on all sides by top, bottom, front, and back plates **204**, **206**, **208**, and **210**, respectively. The plates **204**, **206**, **208**, **210** or other elements used to define the conduit **212** can be sealed to one another and to the outer tubes **102**, **102'**, such as by fluid-tight welds, brazing, and the like. Such seals can protect the interior of the conduit **212** from the surrounding environment.

Thus, when gas passing through a first burner **100** is ignited, the flame produced at the distal end **107** of the venturi tube **106** in the first burner **100** can cross over through the conduit **212** to the distal end **107** of the venturi tube **106'** in the second burner **150**, thereby igniting the contiguous second burner **150**. In such embodiments, the two burners **100**, **150** are therefore either always on or always off together. Furthermore, should the flame **134** in the first burner **100** fail to cross over or be lost in the second burner **150**, the sensor **188** (if employed) can signal the controller **42**, which can respond by cutting off gas to both burners **100**, **150**. This arrangement thus makes it possible to avoid situations in which only one of two burners **100**, **150** is lit and operating.

As described above, powered air can be supplied to both burners **100**, **150** by a common venturi enclosure **152** (see FIG. **7**A). In some alternative embodiments, one of the burners can be coupled to a powered source of air, and can be coupled to the other burner through an air supply conduit in order to feed air to the other burner. An example of such an alternative embodiment is illustrated in FIG. **10**. In the illustrated embodiment of FIG. **10**, powered air is supplied to the interior of the first burner **250** through a port **252**, an air supply conduit **254**, and a side of the outer tube **256** of the first burner **250**. Air is supplied to the second burner **262** through another port (not shown) in the outer tube **256** of the first burner **250**, through another air supply conduit **258**, and through the side of the outer tube **260** of the second burner **262**.

While the illustrated embodiments of FIGS. **7**A-**10** each have a pair of burners **100**, **150**, **250**, **262**, other embodiments can utilize more than two burners by interconnecting additional contiguous burners (e.g., through any combination of common or connected mounting plates **104**, common or connected support plates **184**, venturi enclosure(s) **152** shared by burners, flame ignition conduits **212** extending between burners, and/or air supply conduits **258** extending between burners as described above and illustrated in the figures). Furthermore, although a common source of powered air can be used to supply air to two or more burners **110**, **150**, **250**, **262** (as shown in the illustrated embodiments), air can be supplied to the individual burners **100**, **150**, **250**, **262** on an individual basis. Additionally, the burners **100**, **150** and **250**, **262** of the burner assemblies described and illustrated herein are of the same size. However, in other embodiments, the burners **100**, **150** and **250**, **262** can be different in size (e.g., the second burner **150**, **262** can be smaller than the first burner **100**, **250** in applications in which the first burner **100**, **250** supplies an

inlet tunnel segment **20**A, **20**B of the oven **20** and the second burner **150**, **262** supplies the outlet tunnel segment **20**B, **20**A of the oven **20**).

Returning now to the design of burner **100** illustrated in FIG. **6**, it is noted that the burner **100** has the ability to produce heat in an unusually wide BTU range. In this regard, it should be noted that burners of this general type typically operate at an air to gas ratio variability of 3:1. However, the relatively low BTU draw required of burners in some applications according to the present invention (e.g., in more efficient ovens **20** employing one or more features of the present invention described earlier) can call for an air to gas ratio variability as low as 6:1. Such a lean fuel mixture can result in flame lift-off from conventional burners. Also, a rich air to gas ratio can result in poor combustion. By employing the burner features described above, including a reduced primary air input at the proximal end **112** of the venturi tube **106**, a secondary air supply (e.g., via gaps **123**, **125** in the illustrated embodiments), and/or the air openings **132** in the flame tube **130**, a much richer gas supply can be provided to the burners **110**, **150**, **250**, **262**. Also, it has been found that reduced primary air, combined with the addition of the secondary air supply and the flame tube air openings **132** supports a reduced gas supply level, and hence a reduced BTU production without flame lift off or dirty burning (encountered when there is insufficient oxygen to support the flame **134**).

FIG. **11** is a top plan view of selected elements of the oven **20** illustrated in FIGS. **1**-**4**. Gas inlets **251**, **253** are coupled to and supply gas to the gas supply tubes **170**, **172**, respectively (all of which are shown on the outside of the front wall **254** of the oven **20**), which lead to the burners **102**, **102'** (see FIGS. **7**A and **7**B). Also, the blower **155** supplies air to the venturi enclosure **152** via the air inlet **154** as described above. Extending from the other side of the front wall **254** are the flame tubes **130** and **130'**. A barrier **258** is located at the distal ends **256** and **256'** of the flame tubes **130**, **130'** and is positioned between the two flame tubes **130**, **130'**. The barrier **258** can be a plate or any other structure separating the flames **134** of the two tube flame tubes **130**, **130'** from each other. Alternatively or in addition, the barrier **258** can be positioned to separate the heater plenums **68**, **70** from each other (e.g., can extend downwardly between the heater plenums **68**, **70** in the illustrated embodiment of FIG. **11**), so that heat produced by the first burner **100** associated with one flame tube **130** is directed into one heater plenum **70**, and heat produced by the second burner **150** associated with the other flame tube **130'** is directed into the other heater plenum **68**.

Operator Interface

FIG. **17** is a schematic illustration of an alternative embodiment of the control system for the oven **20**. In the illustrated embodiment of FIG. **17**, a microprocessor-based controller **42'** (e.g., model FP0-C14 manufactured by Panasonic) can be coupled to a separate operator interface **690** (e.g., model GT-30 manufactured by Panasonic). Alternatively, the controller **42'** and the operator interface **690** can be incorporated into the same unit, if desired. The operator interface **690** can include a touchscreen display for displaying data from and/or inputting data to the controller **42'**.

In some embodiments, the operator interface **690** can include a color liquid crystal display ("LCD") and can have a diagonal screen size of 5.7". The resolution of the display can be 320 pixels by 240 pixels and can support sixteen colors. Other embodiments of the operator interface **690** can include a monochrome display and/or can be of other sizes, color depths, and resolutions.

FIGS. **18** to **23** illustrate displays for monitoring and controlling the oven **20** according to an embodiment of the present invention. In some embodiments, the operator interface **690** includes two or more different screens for access by a user (e.g., oven operator, oven service or setup personnel, and/or oven manufacturers) in order to control operation of the oven **20**. A significant advantage of this feature is the ability to hide one or more screens from some users (e.g., oven operators), while still enabling other users (e.g., oven service or setup personnel and/or oven manufacturers) to access and adjust controls of the oven **20**. Screens and user operable controls can be hidden from users by the use of buttons or other icons that are not normally visible on the operator interface **690**, by password protection, and the like.

The use of multiple screens enables users to quickly access a greater number of controls organized in an intuitive and logical manner, thereby providing the user with enhanced control over oven operation. In some embodiments, multiple screens having respective user-operable controls can be navigated by selecting buttons or other icons on the interface **690**. Such screens can resemble windows, or can have any other appearance and format desired.

FIGS. **18**A and **18**B show two embodiments of a main screen **700** of the operator interface **690**. The main screen **700** can include an on/off button **705**. In some embodiments, the on/off button **705** can be a first color (e.g., red) or shade when the oven **20** is off and can be a second color (e.g., green) or shade when the oven **20** is on. In these and other embodiments, text or symbols of the on/off button **705** can change to indicate whether the oven **20** is on or off. Pressing the on/off button **705** when the oven **20** is off can signal the controller **42'** to turn the burners **60** and **62** and the fans **72** and **74** on. The oven **20** can then warm up to a predetermined temperature under control of the controller **42'**. Pressing the on/off button **705** when the oven **20** is on can signal the controller **42'** to turn off the burners **60**, **62** and/or fans **72**, **74**. In some embodiments, the controller **42'** turns off the fans **72**, **74** only if the temperature of the oven **20** is below a predetermined threshold. In such embodiments, if the temperature of the oven **20** is above the predetermined threshold, the controller **42'** can continue to run the fans **72**, **74** until the temperature of the oven **20** falls below the predetermined temperature.

In some embodiments of the oven **20**, the conveyor **22** can include a single belt. When the oven **20** is on, the operator interface **690** can display a belt #**1** speed indicator/button **710**. In some embodiments, the speed of belt #**1** can be shown in minutes and seconds, and can indicate the length of time an item placed on the conveyor **22** takes to traverse through the oven **20**. In some embodiments of the oven **20**, the conveyor **22** can include a second belt, belt #**2**.

FIG. **18**B illustrates an embodiment of a main screen **700** for an oven **20** with a conveyor **22** including two belts. A belt #**2** speed indicator/button **715** can show the speed of belt #**2** in minutes and seconds. In ovens **20** with two side-by-side belts, the speed of belt #**1** can indicate the time an item placed on a first conveyor **22** takes to traverse through the oven **20**, whereas the speed of belt #**2** can indicate the time an item placed on a second conveyor **22** takes to traverse through the oven **20**. In those embodiments in which the conveyors **22** are placed in an end-to-end arrangement, the sum of the times for belt #**1** and for belt #**2** can indicate the length of time an item takes to traverse the plenums **68** and **70** of the oven **20**.

Pressing the speed of belt #**1** indicator/button **710** can, in some embodiments, display a data entry screen (not shown) to enable modification of the speed setting for belt #**1**. The data entry screen can display a keypad, a scroll bar, radio buttons, dials, slides, or any other user control allowing an

operator to enter a new data value. The data entry screen can have an enter button which can enter a new data value and return to the previous screen, and can also have a cancel button which can return to the previous screen **755** without modifying the data value. Pressing the speed of belt #**2** indicator/button **715** can, in some embodiments, display a data entry screen to allow modification of the speed setting for belt #**2** in any of the manners just described in connection with the speed of belt #**1** indicator/button **710**.

In some embodiments, a first bar graph **720** can be displayed along the left side of the main screen **700**, and can indicate the percentage of time the first burner **60** has been on during the period the oven **20** has been on. Also or alternatively, a first alphanumeric display **725** can show the percentage of time the first burner **60** has been on. In those embodiments in which the first alphanumeric display **725** is used in conjunction with the first bar graph **720**, the first alphanumeric display **725** can be located anywhere adjacent the first bar graph **720**, such as above the first bar graph **720** as shown in FIGS. **18**A and **18**B. In some embodiments, the first bar graph **720** and/or the first alphanumeric display **725** can be a first color (e.g., green) or shade when the percentage is below a predetermined threshold and can be a second color (e.g., red) or shade when the percentage is above the predetermined threshold. If desired, the first bar graph **720** and/or the first alphanumeric display **725** can be displayed in a plurality of colors to indicate additional thresholds or ranges.

In some embodiments a second bar graph **730** can be displayed along the right side of the main screen **700** and can indicate the percentage of time the second burner **62** has been on during the period the oven **20** has been on. Also or alternatively, a second alphanumeric display **735** can show the percentage of time the second burner **62** has been on. In those embodiments in which the second alphanumeric display **735** is used in conjunction with the second bar graph **730**, the second alphanumeric display **735** can be located anywhere adjacent the second bar graph **730**, such as above the second bar graph **730** as shown in FIGS. **18**A and **18**B. In some embodiments, the second bar graph **730** and/or the second alphanumeric display **735** can be a first color (e.g., green) or shade when the percentage is below a predetermined threshold and can be a second color (e.g., red) or shade when the percentage is above the predetermined threshold. If desired, the second bar graph **730** and/or the second alphanumeric display **735** can be displayed in a plurality of colors to indicate additional thresholds or ranges.

It will be appreciated that the information provided by first and second bar graphs **720**, **730** can be displayed in a number of other forms, including without limitation by pie charts, a series of ramped bars, and the like. Also, the location and size of the first and second bar graphs **720**, **730** shown in FIGS. **18**A and **18**B are presented by way of example only, and can be different in other embodiments.

In some embodiments, the main screen **700** can also include a message display **740** for displaying operating (e.g., energy mode) and/or error messages. Also, the main screen **700** can include a time display **745**. The message and time displays **740**, **745** can have any size and can be located anywhere on the main screen **700** as desired.

The main screen **700**, in some embodiments, can include a temperature display/button **750** which can show a temperature of the oven. The temperature displayed can be that of either plenum **68**, **70**, or can be an average temperature of the plenums **68**, **70**. In some embodiments, two temperature displays are provided, each showing a temperature of a respective portion of the oven **20**. Also, in some embodiments, pressing the temperature display/button **750** can display a temperature setting screen **755** (FIG. **19**, described in greater detail below).

In some embodiments, the main screen **700** can include one or more buttons for accessing one or more oven set-up screens. The buttons can be visible or invisible, and can be password protected, if desired. In the illustrated embodiment of FIGS. **18**A and **18**B, for example, the main screen **700** includes three hidden buttons **760**, **765**, and **770** to access respective set-up screens. The hidden buttons **760**, **765**, and **770** have no visible features displayed on the main screen **700**, but react when pressed. The first hidden button **760** can provide access to a temperature tuning screen **775** (FIG. **20**). The second hidden button **765** can provide access to a belt tuning screen **777** (FIG. **21**) and the third hidden button **770** can provide access to a belt set-up screen **778** (FIG. **22**). Ovens **20** according to embodiments of the present invention can have any one or more (or none) of these screens **775**, **777**, **778**.

FIG. **19** illustrates a temperature setting screen **755** according to an embodiment of the present invention. The temperature setting screen **755** can display the first bar graph **720**, the second bar graph **730**, the first alphanumeric display **725**, and the second alphanumeric display **735** in a manner similar to that discussed previously with regard to the main screen **700**. The temperature setting screen **755** can also display actual and/or desired temperatures for one or more portions of the oven **20**. For example, the temperature setting screen **755** illustrated in FIGS. **18**A and **18**B can display a first actual temperature **780** indicating the temperature in the left oven segment **20**A, and a second actual temperature **785** indicating the temperature in the right oven segment **20**B. The temperature setting screen **755** can also or instead display a first temperature setpoint **790** for the left oven segment **20**A and a second temperature setpoint **795** for the right oven segment **20**B.

The temperature setpoints can be target temperatures that the controller **42'** can attempt to maintain in each oven segment **20**A, **20**B. In some embodiments, pressing the first temperature setpoint display **790** for the left oven segment **20**A can display a data entry screen (as discussed previously) to allow modification of the first temperature setpoint, while pressing the second temperature setpoint display **795** for the right oven segment **20**B can also display a temperature entry screen (as discussed previously) to allow modification of the second temperature setpoint. The temperature setting screen **755** can also be provided with a back button **800** that can be pressed to display the main screen **700**.

With reference again to the illustrated embodiment of the main screen **700** in FIGS. **18**A and **18**B, pressing the hidden button **760** on the main screen **700** of the operator interface **690** can display a temperature tuning screen **775** as shown in FIG. **20**. The temperature tuning screen **775** can enable an operator to monitor and modify control parameters of the oven **20**. Some embodiments of the oven **20** can use a proportional integral derivative ("PID") control scheme. For example, the controller **42'** can utilize a PID control scheme for controlling the burners **60** and **62**. The PID control scheme enables the controller **42'** to achieve and maintain the temperatures within the oven segments **20**A, **20**B close to their temperature setpoints.

In some embodiments, the temperature tuning screen **775** can include one or more PID displays for one or more respective burners **60**, **62** of the oven **20**. For example, in the illustrated embodiment of FIG. **20**, the temperature tuning screen **775** displays a burner #**1** proportional gain indicator/button **810**, a burner #**1** integral time indicator/button **815**, a burner

#1 derivative time indicator/button **820**, and a burner #1 control cycle time indicator/button **825**. In some embodiments, an operator can press any of these indicators **810**, **815**, **820**, **825** to display a data entry screen (as discussed previously), thereby allowing modification of each parameter. Alternatively or in addition, pressing a burner #1 autotune button **830** can instruct the controller **42'** to perform an autotuning function that can automatically determine the optimum value for each of the parameters.

The temperature tuning screen **775** can also display a burner #2 proportional gain indicator/button **835**, a burner #2 integral time indicatoributton **840**, a burner #2 derivative time indicatoributton **845**, and a burner #2 control cycle time indicatoributton **850**. In some embodiments, an operator can press any of these indicators **835**, **840**, **845**, **850** to display a data entry screen (as discussed previously), thereby allowing modification of each parameter. Alternatively or in addition, pressing a burner #2 autotune button **855** can instruct the controller **42'** to perform an autotuning function that can automatically determine the optimum value for each of the parameters.

In some embodiments, the temperature tuning screen **775** can display one or more buttons for accessing set-up screens for energy saving modes. It will be appreciated that such buttons can also or instead be located on other screens of the operator interface **690**. With reference to the embodiment of FIG. **20**, an energy saving mode #2 button **860** can access an energy saving mode #2 screen **865** (FIG. **23**A). The energy saving mode #2 screen **865** can display the time that the oven **20** is to remain in energy saving mode #2 once the oven **20** enters energy saving mode #2. The energy saving mode #2 screen **865** can include a mode #2 hours indicator/button **870**, a mode #2 minutes indicator/button **875**, and a mode #2 seconds indicator/button **880**. In some embodiments, pressing any of these indicator/buttons **870**, **875**, **880** can display a data entry screen (as discussed previously), enabling an operator to modify the time setting for energy saving mode #2. The energy saving mode #2 screen **865** can also be provided with a back button **800** for returning to the temperature tuning screen **775**.

The temperature tuning screen **775** can also display an energy saving mode #3 button **885**. Pressing the energy saving mode #3 button **885** can access an energy saving mode #3 screen **890** (FIG. **23**B). The energy saving mode #3 screen **890** can display the time that the oven **20** is to remain in energy saving mode #3 once the oven **20** enters energy saving mode #3. The energy saving mode #3 screen **890** can include a mode #3 hours indicator/button **895**, a mode #3 minutes indicator/button **900**, and a mode #3 seconds indicator/button **905**. In some embodiments, pressing any of the indicator/buttons **895**, **900**, **905** can display a data entry screen (as discussed previously), enabling an operator to modify the time setting for energy saving mode #3. The energy saving mode #3 screen **890** can also be provided with a back button **800** for returning to the temperature tuning screen **775**.

The temperature tuning screen **775** can also display an energy saving mode #4 button **910**. Pressing the energy saving mode #4 button **910** can access an energy saving mode #4 screen **915** (FIG. **23**C). The energy saving mode #4 screen **915** can display the time that the oven **20** is to remain in energy saving mode #4 once the oven **20** enters energy saving mode #4. The energy saving mode #4 screen **915** can include a mode #4 hours indicator/button **920**, a mode #4 minutes indicator/button **925**, and a mode #4 seconds indicator/button **930**. In some embodiments, pressing any of the indicator/buttons **920**, **925**, **930** can display a data entry screen (as discussed previously), enabling an operator to modify the time setting for energy saving mode #4. The energy saving mode #4 screen **915** can also be provided with a back button **800** for returning to the temperature tuning screen **775**.

In some embodiments, the main screen **700** is provided with a back button **800**, which can be pressed to return the user to the main screen **700**.

With reference again to the illustrated embodiment of the main screen **700** in FIGS. **18**A and **18**B, pressing the second hidden button **765** on the main screen **700** of the operator interface **690** can display a belt tuning screen **777** (FIGS. **21**A and **21**B). FIG. **21**A is an embodiment of a display for an oven **20** having a single belt, and FIG. **21**B is an embodiment of a display for an oven **20** having two belts. As with temperature control of the oven **20** described above, some embodiments of the controller **42'** can control the operation of the belts using a PID control scheme. The belt tuning screen **777** can enable an operator to monitor and modify the parameters of the PID control.

The belt tuning screen **777** illustrated in FIG. **21**A displays a front belt proportional gain indicator/button **935**, a front belt integral time indicator/button **940**, a front belt derivative time indicator/button **945**, and a front belt control cycle time indicator/button **950**. In some embodiments, an operator can press any of these indicator/buttons **935**, **940**, **945**, **950** to display an entry screen, thereby enabling the operator to modify each parameter. Alternatively or in addition, pressing a front belt autotune button **955** can instruct the controller **42'** to perform an autotuning function that can automatically determine the optimum value for each of the parameters.

The belt tuning screen **777** for an oven **20** with two belts can also display a back belt proportional gain indicator/button **960**, a back belt integral time indicator/button **965**, a back belt derivative time indicator/button **970**, and a back belt control cycle time indicator/button **975**. An operator can press any of these indicators **960**, **965**, **970**, **975** to display an entry screen, thereby enabling the operator to modify each parameter. Alternatively or in addition, pressing a back belt autotune button **980** can instruct the controller **42'** to perform an autotuning function that can automatically determine the optimum value for each of the parameters.

In some embodiments, the belt tuning screen **777** is provided with a back button **800**, which can be pressed to return the user to the main screen **700**.

With reference again to the illustrated embodiment of the main screen **700** in FIGS. **18**A and **18**B, pressing the third hidden button **770** on the main screen **700** can display a belt set-up screen **778** (see FIG. **22**). In some embodiments, the belt set-up screen displays different buttons for two or more different belt lengths of the belts used in the conveyor **20**. In the illustrated embodiment of FIG. **22**, for example, the belt set-up screen **778** displays three buttons **1000**, **1005**, **1010** representing different belt lengths for a front belt of the conveyor **22**, and three buttons **1015**, **1020**, **1025** representing different belt lengths for a back belt of the conveyor **22**. The buttons can represent a front belt short-length belt **1000**, a front belt mid-length belt **1005**, a front belt long-length belt **1010**, a back belt short-length belt **1015**, a back belt mid-length belt **1020**, and a back belt long-length belt **1025**.

In some embodiments the button for the belt length selected for each belt can be displayed in a first color (e.g., green) or shade, and the buttons for the belt lengths not selected can be displayed in a second color (e.g., red) or shade. Pressing a button that is not presently selected can make the belt length associated with the pressed button become the active belt length, and can deselect the belt length previously selected. Pressing a button that is already selected for at least one of the belts of the conveyor **22** can deselect the

belt length associated with that button, placing that belt into an inactive mode (e.g., a mode where the oven **20** has only one belt). In some embodiments, pressing a button that is already selected for one of the belts of the conveyor **22** has no impact on the oven **20**. Also, in some embodiments, a front belt active display **1030** and a back belt active display **1035** can display in a first color (e.g., green) or shade when a belt length has been selected for that belt and can display in a second color (e.g., red) or shade when no belt length is selected. In these and other embodiments, text associated with the front belt length and the back belt length can change to indicate whether a belt length has been selected or no belt length has been selected. In some embodiments, the belt set-up screen **778** is provided with a back button **800**, which can be pressed to return the user to the main screen **700**.

The embodiments described above and illustrated in the figures are presented by way of example only and are not intended as a limitation upon the concepts and principles of the present invention. As such, it will be appreciated by one having ordinary skill in the art that various changes in the elements and their configuration and arrangement are possible without departing from the spirit and scope of the present invention as set forth in the appended claims. For example, the oven controller **42** in a number of the embodiments described above is responsive to one or more temperature sensors **80**, **82** and/or position sensors **79**, **81**, **83**, **85** by changing the BTU output of one or more burners **60**, **62** and/or by changing the speed of one or more fans **72**, **74**. In these and other embodiments, the controller **42** can be responsive to an amount of conveyor movement detected by one or more suitable sensors (e.g., rotary encoder(s), other optical or mechanical sensors positioned to detect the amount of movement of the conveyor, and the like). In this manner, such sensor(s) can send signals to the controller **42** to change the BTU output of one or more burners **60**, **62** and/or to change the speed of one or more fans **72**, **74** based upon the amount of movement of the conveyor **22**—and therefore the amount of movement of a pizza or other food on the conveyor **22**.

What is claimed is:

1. A conveyor oven for cooking food product, the conveyor oven comprising:

a tunnel within which food product is cooked;

a conveyor movable to convey food product through the tunnel;

a heating element operable to generate heat to be provided to the tunnel;

a fan operable to move air in the tunnel;

an input device remote from the oven by which information reflecting food product to be cooked is transmitted; and

a controller that controls at least one of the fan and the heating element, the controller changes operation of the oven to an energy saving mode, in which the fan moves air in the tunnel at a reduced speed, in response to passage of a period of time indicating the absence of food product from the tunnel,

the controller also changes the output of the heating element in response to a change in oven temperature to maintain the oven substantially at a cooking temperature after the oven enters the energy saving mode, and

the controller also changes operation of the at least one of the fan and the heating element from the energy saving mode to a cooking mode prior to food product being placed on the conveyor in response to a signal initiated by the input device.

2. The oven of claim **1**, wherein the input device is a user-manipulatable control.

3. The oven of claim **1**, wherein the input device is a cash register.

4. The oven of claim **1**, wherein the input device is a keypad.

5. The oven of claim **1**, wherein the input device is an optical sensor.

6. The oven of claim **1**, wherein the input device is a limit switch.

7. The oven of claim **1**, wherein the input device is a computer.

8. The oven of claim **1**, wherein the input device communicates with the oven wirelessly.

9. The oven of claim **1**, wherein the input device communicates with the oven via the Internet.

10. A method of operating a conveyor oven for cooking food product, the method comprising:

operating a conveyor movable to convey food product through a tunnel;

operating a heating element operable to generate heat to be provided to the tunnel;

operating a controller;

sensing at least one of a temperature in the oven and the presence of food product on the conveyor;

measuring a period of time indicating the absence of food product from the oven;

changing operation of the oven from a cooking mode to an energy saving mode by the controller after passage of the period of time indicating the absence of food product from the oven, wherein in the energy saving mode (i) a fan moves air in the oven at a reduced speed and (ii) in response to a change in oven temperature the controller changes output of the heating element to maintain the oven substantially at a cooking temperature;

receiving a signal representative of an order for cooked food product initiated by an input device operatively associated with the oven; and

changing operation of the fan from the energy saving mode to the cooking mode by the controller responsive to the signal representative of an order for cooked food product.

11. The method of claim **10**, wherein the oven detects the presence of a food product on the conveyor.

12. The method of claim **10**, further comprising delaying entering the cooking mode following receiving the signal representative of an order for cooked food product.

13. The method of claim **12**, further comprising determining a period of delay based at least in part upon a desired length of time until initiation of a cooking process.

14. The method of claim **13**, further comprising determining the period of delay based at least in part upon a sensed temperature of the oven.

15. The method of claim **13**, further comprising determining the period of delay based at least in part upon a length of time needed to prepare food product for cooking.

16. A conveyor oven for cooking food product wherein the conveyor oven has a cooking mode and an energy saving mode, the conveyor oven comprising:

an oven chamber in which food is cooked;

a conveyor for moving food product through the oven chamber;

a heating element operable to generate heat to be provided to the oven chamber;

a fan operable to move air in the oven chamber;

at least one sensor positioned to detect at least one of a temperature in the oven and the presence of food product on the conveyor;

an input device remote from the oven by which information reflecting food product to be cooked is transmitted; and

a controller that controls at least one of the fan, the heating element and the conveyor, the controller changes the operation of the fan from a cooking mode to an energy saving mode, in which the fan moves air in the oven chamber at a reduced speed, in response to (i) detection of the absence of food product from the oven chamber based at least in part upon the operation of the sensor and (ii) passage of a first period of time indicating the absence of food product from the oven,

the controller also changes the output of the heating element in response to a change in oven temperature to maintain the oven substantially at a cooking temperature after the oven enters the energy saving mode, and

the controller also changes operation of the fan from the energy saving mode to the cooking mode in response to receiving a signal initiated by the input device reflecting food product to be cooked.

17. The conveyor oven of claim **16** wherein in the energy saving mode, after the passage of a second period of time the fan is turned off.

18. The conveyor oven of claim **16** wherein in the energy saving mode, after the passage of a second period of time the output of the heating element is reduced.

19. The conveyor oven of claim **1**, wherein the conveyor oven detects the presence of a food product on the conveyor.

20. The conveyor oven of claim **1**, wherein the controller changes operation of the at least one of the fan and the heating element from the energy savings mode to the cooking mode following a period of delay.

21. The conveyor oven of claim **1**, wherein the controller also determines a period of delay based at least in part upon a desired length of time until initiation of a cooking process.

22. The conveyor oven of claim **21**, wherein the controller determines the period of delay based at least in part upon a sensed temperature of the oven.

23. The conveyor oven of claim **21**, wherein the controller determines the period of delay based at least in part upon a length of time needed to prepare food product for cooking.

24. The conveyor oven of claim **1** wherein in the energy saving mode, after the passage of a second period of time the fan is turned off.

25. The conveyor oven of claim **1** wherein in the energy saving mode, after the passage of a second period of time the output of the heating element is reduced.

26. The conveyor oven of claim **1**, wherein the input device is at least one sensor positioned to detect at least one of a temperature in the oven and the presence of food product upon the conveyor.

27. The conveyor oven of claim **1**, wherein the input device is an optical sensor positioned to detect the presence of food product on the conveyor.

28. The conveyor oven of claim **1**, wherein the input device detects a location of food product with respect to the tunnel.

29. The conveyor oven of claim **1**, wherein the input device is at least one sensor positioned adjacent at least one of an entrance of the tunnel and an exit of the tunnel.

30. The conveyor oven of claim **29**, wherein the at least one sensor is at least one optical sensor positioned to detect the presence of food product on the conveyor.

31. The method of claim **10**, wherein the input device is a user-manipulatable control.

32. The method of claim **10**, wherein the input device is a cash register.

33. The method of claim **10**, wherein the input device is a keypad.

34. The method of claim **10**, wherein the input device is an optical sensor.

35. The method of claim **10**, wherein the input device is a limit switch.

36. The method of claim **10**, wherein the input device is a computer.

37. The method of claim **10**, wherein the input device communicates with the oven wirelessly.

38. The method of claim **10**, wherein the input device communicates with the oven via the Internet.

39. The method of claim **10**, further comprising:

measuring a second period of time; and

turning the fan off by the controller after passage of the second period of time.

40. The method of claim **10**, further comprising:

measuring a second period of time; and

reducing the output of the heating element after passage of the second period of time.

41. The method of claim **10**, wherein the input device is at least one sensor positioned to detect at least one of a temperature in the oven and the presence of food product upon the conveyor.

42. The method of claim **10**, wherein the input device is an optical sensor positioned to detect the presence of food product on the conveyor.

43. The method of claim **10**, wherein the input device detects a location of food product with respect to the tunnel.

44. The method of claim **10**, wherein the input device is at least one sensor positioned adjacent at least one of an entrance of the tunnel and an exit of the tunnel.

45. The method of claim **44**, wherein the at least one sensor is at least one optical sensor positioned to detect the presence of food product on the conveyor.

46. The conveyor oven of claim **16**, wherein the input device is a user-manipulatable control.

47. The conveyor oven of claim **16**, wherein the input device is a cash register.

48. The conveyor oven of claim **16**, wherein the input device is a keypad.

49. The conveyor oven of claim **16**, wherein the input device is an optical sensor.

50. The conveyor oven of claim **16**, wherein the input device is a limit switch.

51. The conveyor oven of claim **16**, wherein the input device is a computer.

52. The conveyor oven of claim **16**, wherein the input device communicates with the oven wirelessly.

53. The conveyor oven of claim **16**, wherein the input device communicates with the oven via the Internet.

54. The conveyor oven of claim **16**, wherein the controller changes operation of the at least one of the fan and the heating element from the energy savings mode to the cooking mode following a period of delay.

55. The conveyor oven of claim **16**, wherein the controller also determines a period of delay based at least in part upon a desired length of time until initiation of a cooking process.

56. The conveyor oven of claim **55**, wherein the controller determines the period of delay based at least in part upon a sensed temperature of the oven.

57. The conveyor oven of claim **55**, wherein the controller determines the period of delay based at least in part upon a length of time needed to prepare food product for cooking.

58. The conveyor oven of claim 16, wherein the input device is an optical sensor positioned to detect the presence of food product on the conveyor.

59. The conveyor oven of claim 16, wherein the input device detects a location of food product with respect to the oven chamber.

60. The conveyor oven of claim 59, wherein the input device is at least one sensor positioned adjacent at least one of an entrance of the oven chamber and an exit of the oven chamber.

61. The conveyor oven of claim 59, wherein the at least one sensor is at least one optical sensor positioned to detect the presence of food product on the conveyor.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 8,281,779 B2
APPLICATION NO. : 12/233969
DATED : October 9, 2012
INVENTOR(S) : Wiker et al.

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

In the Specification,

Column 3, line 64, delete "an" and replace with --a--;

Column 7, line 21, delete "FIG. 3B" and replace with --FIG. 3--;

Column 7, line 25, delete "44a-44h" and replace with --42a-42h--;

Column 26, line 59, delete "110" and replace with --100--;

Column 27, line 21, delete "110" and replace with --100--; and

Column 31, lines 12, 13, and 14, delete each instance of "indicatoributton" and replace with --indicator/button--.

Signed and Sealed this
Sixteenth Day of July, 2013

Teresa Stanek Rea
Acting Director of the United States Patent and Trademark Office